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COMPREHENSIVE FRAMEWORK STUDY

CALIFORNIA REGION

Main Report

MAY 1972

Prepared by:
California Region Framework Study Committee
For Pacific Southwest Inter-Agency Committee
Water Resources Council

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Comprensive Framework Study, CALIFORNIA REGION.

MAIN REPORT.

This report of the California Region Framework Study Committee was prepared at field-level and presents a framework program for the development and management of the water and related land resources of the California Region. This report is subject to review by the interested Federal agencies at the department level, by the Governors of the affected States, and by the Water Resources Council prior to its transmittal to the Congress for its consideration.

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MAY 1972

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293p.

Prepared by the
California Region Framework Study Committee

For the
Pacific Southwest Inter-Agency Committee

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FRAMEWORK STUDY COMMITTEE

The California Region Framework Study Committee directed preparation of the Main Report and its 18 appendixes. Representatives of the following agencies comprise this Committee:

CALIFORNIA AGENCIES

HUMAN RELATIONS AGENCY

Public Health, Department of

RESOURCES AGENCY

Colorado River Board of California

Conservation, Department of

Fish and Game, Department of

Navigation and Ocean Development, Department of

Parks and Recreation, Department of

Reclamation Board

Water Resources, Department of

Water Resources Control Board

NEVADA AGENCY

COLORADO RIVER COMMISSION OF NEVADA

OREGON AGENCY

STATE WATER RESOURCES BOARD

INTERSTATE AGENCY

KLAMATH RIVER COMPACT COMMISSION

UNITED STATES AGENCIES

AGRICULTURE, DEPARTMENT OF

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Mines, Bureau of
National Park Service
Outdoor Recreation, Bureau of
Reclamation, Bureau of
Sport Fisheries and Wildlife, Bureau of

INTERNATIONAL BOUNDARY AND WATER COMMISSION

LABOR, DEPARTMENT OF

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*Now part of the Environmental Protection Agency

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SUMMARY

This study report, prepared by state and federal agencies under the guidance of the United States Water Resources Council, outlines alternative uses of water and related land resources in the California Region between 1965 and 2020. The Region includes all of California and 7 percent of Oregon. → page A-1

In 1965, after more than a century of development, the Region supported 18 million people. Although it still led the United States in agricultural production, it had become increasingly dependent upon manufacturing and the service industry.

By 2020, the population of this Region is estimated to be $2\frac{1}{2}$ to 3 times that of 1965; its per capita income, more than 4 times that of 1965. Such growth will increase the demand upon land and water and will intensify existing environmental problems. The need for food and fiber will more than double; and that for recreational opportunities will triple. The need for reduction in damage from flood, erosion, and wildfire will be 3 to 6 times, and that for electric power will be 20 to 25 times that of 1965. Excluding the need for water to enhance the fishery, to improve water quality, to provide streamside recreation, and to modify outflow from the Sacramento-San Joaquin River Delta, the need for water will be 1.3 to 1.6 times that of 1965. A much greater increase, 2 or $2\frac{1}{2}$ times, would be required except that projected increases in crop yields will allow agriculture to meet food and fiber needs without an additional 25 to 30 million acre-feet of water that would otherwise be needed to irrigate crops.

Requirements for additional irrigated cropland range from 2.5 million acres to 0.7 million acres depending upon which of the alternative assumptions of economic activity are considered.

The resources of the Region can meet most needs of the inhabitants of the Region until 2020. Except for conveyance features,

existing major water supply works -- together with those under construction -- generally will satisfy the immediate water needs of the first time frame, 1965-1980, and some of those of the second time frame, 1980-2000. The Region can reduce flood, fire, and erosion damages to a practicable minimum. Some problems of choice will exist among uses and between preservation and development. Lack of suitable land will limit grazing, timber production, waterfowl habitat, and ocean beach recreation. Financial, legal, and physical restrictions could limit recreation development to the point that only about one-third of the recreation needs will be met. The Framework Study finds that present lag in required waste water treatment probably will not be overcome until 2000. The State of California has indicated, however, that development of adequate treatment facilities in its portion of the Region will proceed at a much faster rate than that assumed for this finding.

The South Coastal and Colorado Desert Subregions of the California Region and other areas within or joining the Colorado River Basin are dependent to an important degree on water from the Colorado River. As regulation and use of water within the Basin and export of water from the Basin have proceeded, the mineral quality of the river has steadily deteriorated. Federal agencies and the states of the area have proposed a basinwide salinity control program to halt the salinity increase and to lower the salinity if possible. It is imperative that feasibility studies and implementation steps for this program proceed rapidly.

The combined rate of federal and nonfederal investment necessary to meet the need for water-related development will range from $700 to $800 million per year during the first time period. Current (1966-1970) annual expenditures are about $1 billion, of which the reported annual federal investment of $160 million has been only about one-half the amount necessary.

Present federal and nonfederal ongoing programs of resource planning, management, and development should continue with the view of recognizing the impacts, influences, and alternatives presented in this report and supporting documents with emphasis on the early action program. Planning must be sufficiently flexible so as to overcome the difficulties inherent in projecting needs. If growth rates prove more or less rapid than those projected for this study, the sequence of implementing most proposals will remain as planned even though the date of the implementation is advanced or delayed. Planning must provide for acceptable ways to assess the impact of alternative plans upon existing development and upon the environment.

PART I - INTRODUCTION

Under the direction of the United States Water Resources Council and the Pacific Southwest Inter-Agency Committee, the California State-Federal Interagency Group organized the California Region Framework Study Committee to guide the study of the present and projected future development of water and related land resources in the California Region. The Region is one of 18 such regions in the coterminous United States. The Water Resources Planning Act of 1965 (Public Law 89-80, 79 Stat. 244) authorized the study.

The Water Resources Council expects the Framework Study to act as a guide to the best use of water and related land resources so as to meet needs between 1965 and 2020.

cont The studies analyze water and related land resources problems, and appraise the probable nature, extent, and timing of solutions to those problems.

This California Region report considers problems of agricultural, industrial, and domestic water supply. It considers problems of irrigation, drainage, electric power, flood control, water quality, navigation, watershed management, fish, wildlife, recreation, minerals, and the shoreline. Wherever possible, it identifies environmental effects.

The period considered extends from 1965 to 2020. Projections of population, economic development, and costs, etc., are compared with existing conditions in 1965. Thus, all evaluations considered water projects operating before or during 1965. Projects placed in operation after 1965 are included as appropriate.

Three rates of population and economic growth have been used to project the needs of 1980, 2000, and 2020 and the effect of these needs upon water and related resources. The lowest rate (Series D-1970) projects a population of 45 million in 2020. The other two rates (Base Plan and OBERS) each project a population of 55 million

in 2020, but distribute that population differently between the northern and southern area of the Region. The actual population in 1965 was 18 million.

The report summarizes the results of studies reported upon in 18 appendixes whose titles appear on the inside of the front cover. The needs for water, land, food, and fiber, etc., are compared with the availability of the resources. General data, approximations and experienced judgment supplement detailed information whenever needed to fill in the broad guidelines provided.

Concurrent with the Framework Studies, the State of California's Department of Water Resources was engaged in its Coordinated Statewide Planning Program. This is the State's core water resources planning program and is a continuation of activities that commenced upon publication of the California Water Plan in 1957. In recent years, annual investments in this and closely related studies have totalled more than $1 million. One of the recent products from this program is an up-to-date summary of California's views regarding its future water and related requirements and appropriate measures to meet those needs, which was published by the Department of Water Resources early in 1971 as Bulletin No. 160-70, "Water for California - the California Water Plan - Outlook in 1970".

PART II - REGIONAL CHARACTERISTICS

The California Region includes all of California and 7 percent of Oregon. About 900 miles long, it occupies 105,678,000 acres*, or about 165,000 square miles. For hydrographic purposes, this study has divided the Region into 11 subregions (Figure A-1).

LAND FORMS

Skirting the California coastline from north to south are a series of mountain ranges, the Klamath Mountains, the California Coast Range, the Transverse, and the Peninsular Ranges. Inland from the Coast Range, the Central Valley lies west of the Southern Cascade Range and the Sierra Nevada. Farther inland along the eastern side of the Region lie the Modoc Plateau, the ranges of the Great Basin, the Mojave Desert, and the Salton Trough.

The rugged Klamath Mountains ascend to about 9,000 feet. The principal rivers, Klamath and Trinity, have cut deep, twisting gorges through the mountains.

The California Coast Range, markedly linear, extends for nearly 600 miles along the coast, southeast from the Klamath Mountains. Their numerous, often indistinct ridges rise from 2,000 to 7,000 feet and lie separated by the valleys of the Mad, Eel, Russian, and Salinas Rivers, as well as by those of smaller streams.

The Transverse Range, of which Santa Rosa and Santa Cruz Islands represent a seaward extension, breaks the southeastward grain of topography that typifies much of the Region and instead trends eastward as a group of linear ranges. In this range the San Gabriel Mountains, just north and northeast of Los Angeles, reach peak elevations of almost 10,000 feet. Los Angeles itself lies on a broad coastal plain not much above sea level.

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*104,182,000 acres of land; 1,496,000 acres of water.
101,564,000 acres in California; 4,114,000 acres in Oregon.

The Peninsular Range extends southward into Baja California. Although Mount San Jacinto, the highest peak, reaches 10,831 feet, the general altitude is lower than that of the ranges to the north.

The Central Valley dominates the Region inland from the California Coast Range. This province is a vast elliptical plain 400 miles long and 50 miles wide. Its floor varies in elevation from below sea level in the Delta to a few hundreds of feet above sea level. The southward-flowing Sacramento River system drains the northern half of this valley; the northward-flowing San Joaquin River system drains the southern half. The two rivers converge in the Sacramento-San Joaquin Delta. From here, the water flows, via San Francisco Bay, through the only exit from the mountain-rimmed valley, the Golden Gate.

The Southern Cascade Range contains two prominent volcanic mountains: Lassen Peak (10,457 feet) and towering Mount Shasta (14,162 feet). The width of the range, throughout most of its north-south length, is less than 25 miles.

In the Sierra Nevada, a great westward-dipping fault block 385 miles long and 85 miles wide, lofty mountain peaks tower above precipitous gorges and canyons. About a dozen major streams traverse the gentle western slope of the range and flow into the Sacramento and San Joaquin Rivers. Some of the valleys or canyons occupied by these streams are more than a half-mile deep. In the northern portion of the Sierra Nevada, the crest elevation of the highest peak is less than 8,500 feet. Crest elevations increase toward the south, culminating in Mount Whitney, 14,495 feet high -- highest mountain in the coterminous United States. The east slope of the Sierra Nevada, throughout much of its length, drops precipitously into Owens Valley and similar depressions to the north. Near Mount Whitney, this drop is almost 2 miles in a horizontal distance of 6 miles.

The Modoc Plateau is a plateau of volcanic rock whose average altitude is 5,000 feet above sea level. Above the plateau, numerous

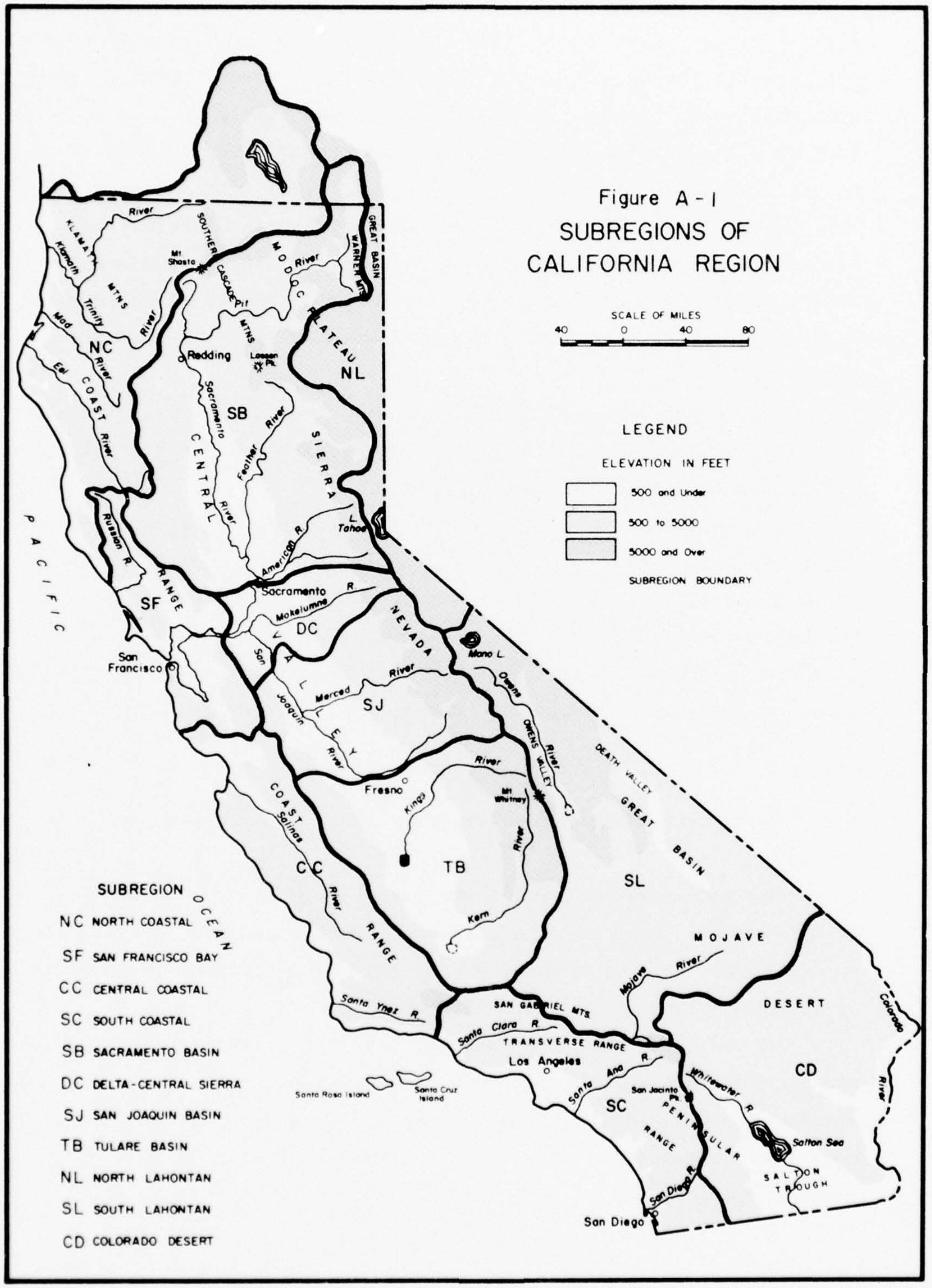


Figure A-1
SUBREGIONS OF CALIFORNIA REGION

volcanic cones rise an additional 2,000 feet. In its extreme northeast corner, the rugged Warner Mountains tower almost a mile. They culminate in Eagle Peak, 9,883 feet above sea level.

The ranges of the Great Basin are extremely rugged, linear mountains that attain altitudes exceeding 14,000 feet. The highest, White Mountain Peak near the Nevada border, rises to 14,242 feet. Also included in this area are the deserts of Owens Valley and Death Valley, the latter containing the lowest point on the North American Continent. It lies only 80 miles from Mount Whitney, but is 282 feet below sea level.

The Mojave Desert, a great expanse of sandy valleys, dry lake bottoms, and short, rugged mountain ranges, extends southward to the California border at the Colorado River.

The Salton Trough, an alluvium-filled basin, lies just north of the Mexican border. A feature peculiar to this desert is that evaporation and seepage dry up most of the rivers in their valleys. The Salton Trough contains the Salton Sea, the largest lake in Southern California, which lies 235 feet below sea level. The highest peaks of the Salton Trough rise almost to 7,500 feet.

GEOLOGY

The geologic history of existing land forms of the Region is complex.

The sediment which fills the huge trough of the Central Valley is miles deep. Some of this sediment is marine, deposited when the valley formed part of a shallow sea; some is continental, deposited by rivers as they eroded adjacent mountains.

In the Southern Cascade Range, lava burst forth forming volcanoes and flows which covered hundreds of square miles. Lassen Peak remains the only active volcano. From 1914 through 1917, during its most recent eruptions, lava and great blasts of gas felled trees for miles around; clouds of steam and ash rose more than 5 miles into the air.

Beneath what today is the Sierra Nevada, massive invasions of molten granite rock pushed, contorted, and melted the layered rocks above them, then cooled and solidified many miles beneath the earth's surface. During the hundred million years that followed, rivers and glaciers exhumed this granite. Today, it lies exposed throughout much of the Sierra Nevada. In the process of erosion, the rivers carried the mud, sand, and gravel downstream and deposited the sediment in a sea to the west. These sediments have since been folded and uplifted, and now lie exposed in the present Coastal Range.

In ancient times, the Gulf of California extended northward through the Salton Trough and inundated both the Imperial and Coachella Valleys. Then the Colorado River, extending its delta, built a land bridge across the Gulf. After the bridge was formed, and the river was again flowing southward to the Gulf, the inland body of water evaporated, exposing the Salton Trough. The land bridge remains as the southern part of the Imperial Valley and the adjoining Mexicali Valley in Mexico.

CLIMATE

Instead of the usual four seasons, most of the Region has two -- a dry, warm summer season, and a wet winter season. The latter generally lasts November through March in the southern part of the Region and lasts October through April in the northern part.

Although the range of latitude within the Region is great, latitude does not influence climate here as strongly as it does elsewhere in the United States. Instead, topography causes isotherms to follow topographic contours and move more from north to south than from east to west. Because of abrupt changes in topography, the range of temperature, the velocity of wind, and the amount of precipitation often vary greatly within a few miles. The Sierra Nevada and Cascade Ranges materially affect the movement of air masses and moisture. In addition to topography, the Pacific Ocean and the movement of the offshore Pacific high pressure areas also influence the climate. The ocean

tends to equalize summer and winter temperatures along the coast and contiguous inland valleys. The offshore Pacific high pressure area moves southward in the winter, permitting cold air masses and winter storms entry into the northern part of the Region. Contrariwise, the high moves northward in the summer, thus deflecting the cool air masses back toward Canada.

Winter storms from the west bring precipitation which usually falls as rain in the valleys and foothills and as snow in the mountains. Figure A-2 shows the mean annual precipitation. Precipitation increases from south to north and falls heaviest on the west side of the mountains below 6,000 feet. When the snowpack melts in the spring, the heaviest runoff descends the west side of the mountains. To the south, heavy rains in early fall often result from cyclonic storms moving in from the southeast.

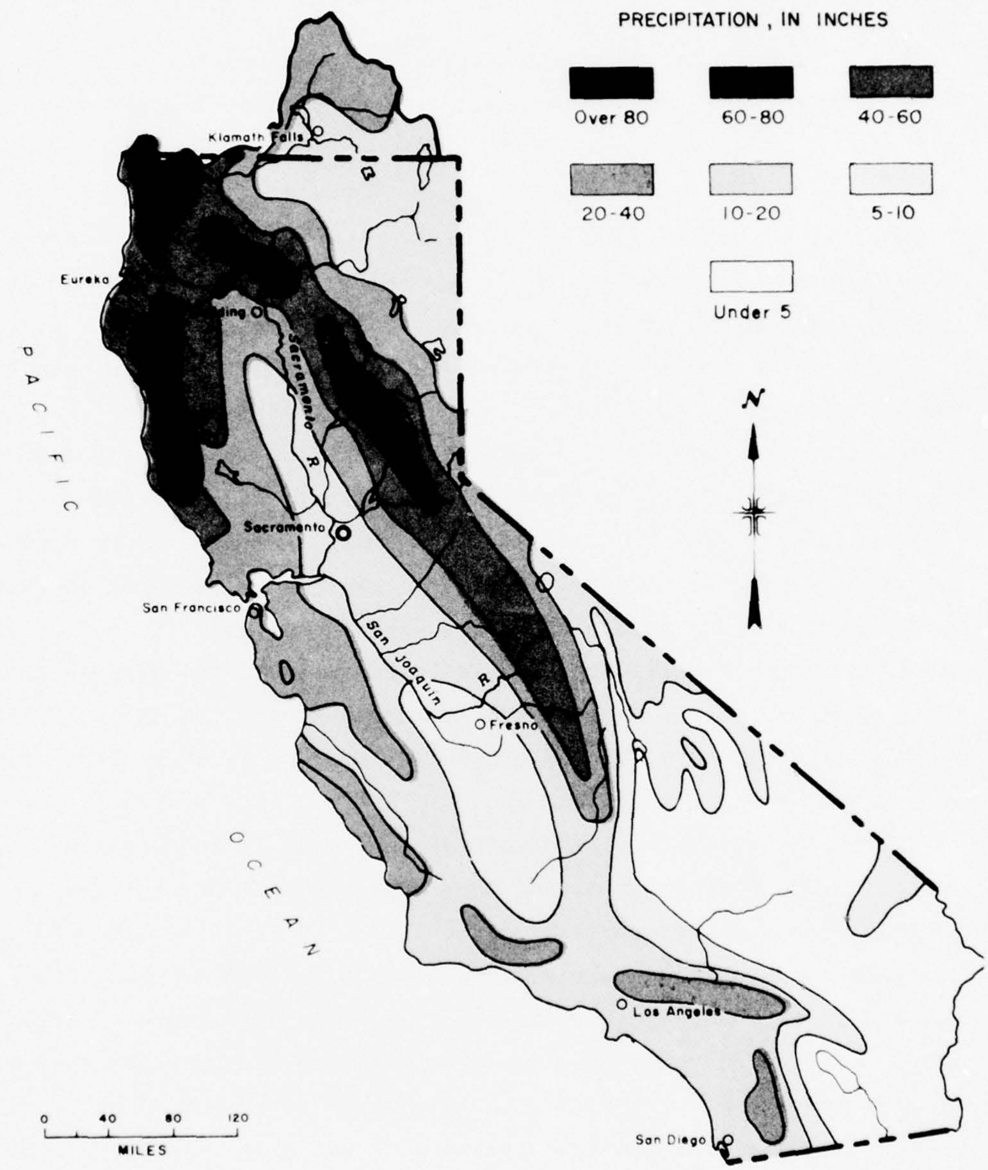
The marine climate of the coast is characterized by warm winters, cool summers, moderate relative humidity, and little daily or seasonal range in temperature. Inland, the more continental climate is characterized by warmer summers, colder winters, lower relative humidity, and greater range in temperatures.

Topography determines the change from marine to continental climates. Topography also controls the amount and the distribution of the winter precipitation. Although snow does fall in the Sierra Nevada at elevations as low as 2,000 feet, it does not remain long below elevation 4,000 feet. In the middle Sierra, snow falls most heavily between 7,000 and 8,000 feet. At Tamarack, in Alpine County, the annual depth averages 450 inches.

Regional temperatures have varied from 134° to -45°. Based on long continued periods of heat, Death Valley is the hottest place in the world.

The frost-free period ranges from 365 days along the extreme south coast to about 260 days along the north coast and in the Central Valley. It averages 100 to 120 days in the northeastern interior valleys, and 282 to 322 days in the Imperial Valley.

Figure A-2: MEAN ANNUAL PRECIPITATION



As a result of the Pacific high pressure area, winds along the coast prevail from the northwest. Elsewhere, local topography, atmosphere pressure gradients, and proximity to the ocean and mountains influence winds.

Relative humidities, comparatively high along the coast, generally increase from south to north. Along the north coast, they are moderately high throughout the year. Within the interior lowland areas west of the Southern Cascade Mountains and the Sierra Nevada they are low in summer and high in winter. East of these ranges, humidities are low in summer. Summer thunderstorms strike the interior in the higher mountains and desert areas. Coastal thunderstorms, weak and infrequent, can occur in any month. Tornadoes strike somewhere in the Region about once a year. Flooding which can occur at any time is worse in winter when prolonged storms accompanied by warm temperatures melt the snowpack. Localized, short-duration convective-type storms sometimes flood small drainages. Dry weather and drought, sometimes persistent, on occasion occur during the winter.

The regional climate favors the growth not only of most crops grown commercially elsewhere in the United States, but also of certain crops that are not grown commercially elsewhere in the United States. Because rainfall distribution generally does not favor dryland crop production, farmers must irrigate.

Three characteristics of climate markedly affect planning in the Region: (1) precipitation, and thus streamflow, differs so widely between summer and winter that farmers in most areas have had to irrigate even their pasturelands, and major cities have had to build reservoirs to insure year-round water; (2) the prevalence of both flood and drought years requires that planners design water systems concordant with both; and (3) the geographic distribution of precipitation and available water supplies does not correspond with distribution of the most desirable irrigable and habitable lands, and water has had to be transported by aqueducts over increasing distances to meet water needs of farms and cities.

HISTORY

Navigators in the service of Spain first approached the California coast in 1542, 50 years after Columbus discovered America. They found a tribally organized, stone-age civilization. Although primarily hunters and gatherers, the Indians practiced some agriculture along the Colorado River. European settlement began in 1769, when the Spanish colonized California.

In 1819, Spain conveyed the Oregon area to the United States under the Spanish-American Treaty and in 1848, Mexico ceded California to the United States under the Treaty of Guadalupe Hidalgo. The Spanish and Mexican periods introduced a pastoral society which established extensive land grants, primarily for cattle raising. But the discovery of gold in 1848 drew settlers from all parts of the world. Of some 200,000 people in California at that time, only about 15,000 were of European descent.

California became a state in 1850; Oregon in 1859.

As the more accessible gold deposits were exhausted, agriculture resumed its dominant position as a means of livelihood. By the 1870s, ships and transcontinental railroads delivered wheat and timber, and later oranges and other fruits and vegetables, to eastern and world markets.

Mining had initiated large-scale water development. By the late 1800s and early 1900s, the experience and capital accumulated at that time moved into irrigation, city water supply, and hydroelectric power development. World War I spurred industrialization and introduced the age of the automobile. Agriculture and industry have continued to expand at accelerating rates through World War II to the present. By 1965, the population had similarly grown to slightly over 18 million.

PART III - REGIONAL ECONOMY

Although by 1965 the Region had become heavily dependent upon manufacturing and service industries, California itself led every other state in the value of agricultural production. As measured in terms of value added within the Region, processing of food and kindred products formed the largest sector of the manufacturing industry. In another area, the aerospace and defense industries led trends toward the production of electronic instruments. In terms of gross regional product alone, the Region's $70 billion in 1965 ranked high when compared with the nations of the world.

PEOPLE

More than 18 million people lived within the Region in 1965, more than 90 percent of them in cities. Urban population concentrations are in Southern California, around the San Francisco Bay area and, less densely, in the Central Valley. About 38 percent of the people were employed. Census data for 1960 indicate that 40 percent of the people were under 14 or over 65 and thus made up only a minor part of the labor force.

FOREST PRODUCTS

The Region differs from others in the West in that it possesses both a large supply and an even larger demand for lumber and wood products.

Mill operators now process 27 different species of wood. Los Angeles County, within the South Coastal Subregion, is one of the major secondary wood processing areas of the country.

In the United States, only Oregon and Washington -- the latter very recently -- surpass California in annual harvesting of timber. California supplies one-seventh of the nation's lumber, most of its commercial redwood, and four-fifths of its sugar pine. Oregon's Klamath Basin supplies pine and fir products and supports the

largest lodgepole pine operation in the West. In 1965, the California Region produced one million Christmas trees and 5.7 billion board feet of lumber -- enough to build 570,000 homes. A growing plywood industry produces one-tenth of the nation's softwood plywood. Wood pulp and particle-board industries, postwar developments, use previously unused mill residues almost exclusively as raw material.

AGRICULTURE

In 1965, the Region's farms produced crops worth about $2.5 billion.

Almost 7,400,000 acres of its cultivated lands lie in the Central Valley within the Sacramento Basin, San Joaquin Basin, Delta-Central Sierra, and Tulare Basin Subregions. This valley produces alfalfa, rice, cotton, sugar beets, tomatoes, and other crops.

More than 1,750,000 acres of cultivated lands lie in coastal valleys, mostly in the San Francisco Bay, Central Coastal, and South Coastal Subregions. Conditions here favor the growth of a wide variety of climatically restricted crops. Artichokes, brussel sprouts, avocados, spinach, flower seeds, and citrus grow here on about one million acres. Such specialty crops are valued at nearly a half billion dollars annually.

More than 600,000 acres of cultivated lands lie in the interior desert valleys of Imperial, Coachella, and Antelope, in the Colorado Desert and South Lahontan Subregions. The Region harvests about 15 percent of its alfalfa on more than 200,000 acres in these valleys. It produces nearly $9 million worth of grapefruit and dates on just 12,000 acres in the Imperial and Coachella Valleys. These valleys also produce much of the Region's supply of winter truck crops.

The Klamath Basin in the North Coastal Subregion grew farm crops valued at more than $27 million in 1965. The most important of these were potatoes and malting barley.

Other cultivated lands lie scattered among mountain plateaus and valleys. Although their total acreage is small, they produce forage and hay crops important to local livestock industries.

MINERALS

Minerals other than gold have proved more lasting in importance to the Region. In 1965, the Region produced 48 mineral commodities valued at $1.6 billion. Petroleum and natural gas provided about two-thirds of this amount; nonmetals, principally cement, sand, and gravel, provided about one-third. The Region produces major amounts of asbestos, boron minerals, sodium sulfate, diatomite, mercury, rare earth metals, and tungsten.

SERVICE, TRADE, AND TRANSPORTATION

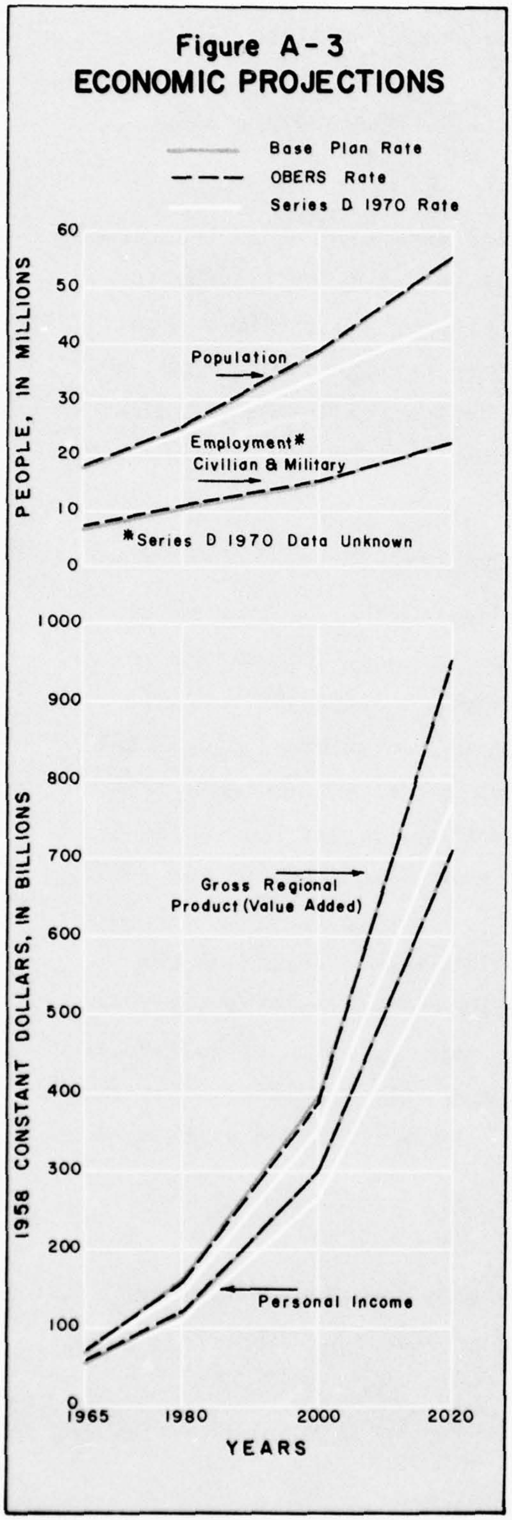
Whether measured by the number of people they employ, or by their contribution to the gross regional product, the service industry ranks ahead of manufacturing, trade, and transportation.

In addition to personal, professional, vocational, and social services, such services include those of government agencies insurance companies, real estate brokers, banking houses, and wholesale and retail distributors, all linked by the communications and utility industries.

International trade exemplifies the economic growth of the Region. California's exports almost doubled between 1962 and 1967; its imports increased more than 60 percent. In terms of dollars, the San Francisco Bay area led in exports. Of 41 customs districts, those of Los Angeles and San Francisco ranked fifth and sixth nationally in value of total trade in 1967.

ECONOMIC AND POPULATION PROJECTIONS

Projections to the year 2020 were made for three different assumptions of economic and population growth; the OBERS, Base Plan, and Series D-1970. (Figure A-3)



The first two projections, OBERS and Base Plan, each assume that the population of the Region in 2020 will approach 55 million. Each, however, distributes this population differently within the Region: the OBERS estimate projects about 8 million more people in Southern California than does the Base Plan. The Series D-1970 projection assumes that the population in 2020 will approach only 45 million.

OBERS Projections

At the request of the Water Resources Council, the Office of Business Economics (OBE), now called the Bureau of Economic Analysis, of the United States Department of Commerce and the Economic Research Service (ERS) of the United States Department of Agriculture developed OBERS population projections and estimated needs for food and fiber production for the entire United States.

Briefly, the method used in developing the OBERS projections for the California Region involved, first, establishing a set of national projections of several measures including population, labor force, employment, hours worked, and product per man-hour. From these were developed national projections of Gross National Product (GNP), personal income, and earnings. Industry breakdowns of GNP and employment were projected to be used in the geographic distributions of the national totals.

The population projections conform to Series C of the U. S. Bureau of the Census, resulting in a 1.3 percent average annual population growth rate between 1965 and 2020. Labor force estimates call for a rise in the overall participation rate from 56.7 percent of the working age population in 1965 to a plateau of 58.3 percent in 1990 which will continue to 2020.

The employment projections assume that fiscal, monetary, and labor market policies will result in a 4.0 percent unemployment rate for all projection periods. Output per man-hour is forecast to increase at an average annual rate of 3.0 percent, somewhat below the post-World War II growth in productivity of 3.2 percent per year.

After gross national production projections were obtained as a function of employment, hours worked, and output per man-hour, the ratio of personal income to GNP was projected into the future based on their relationship between 1948 and 1965. Following reconciliation of the independent regional distributions of income and employment, regional projections of population were based on the assumption that the future population of an area would reflect future economic opportunities. Regional population was made a function of regional employment plus an adjustment to take account of migration of retired persons. The projections were then converted to hydrologic subregional configurations.

The Region's OBERS projection shows that population is expected to increase by nearly 37 million people between 1965 and 2020 -- from 18.1 to 54.9 million. The South Coastal and San Francisco Bay Subregions, which include the Los Angeles-San Diego and San Francisco-Oakland metropolitan areas, accounted for 77 percent of the Region's population in 1965 versus 76 percent of the 2020 projected population. The Central Valley portion of the Region (which includes the Sacramento, San Joaquin, Tulare, and Delta-Central Sierra Hydrologic Subregions) accounted for 15 percent of the Region's population in 1965. By 2020, the Central Valley portion will also decrease slightly to 14 percent of the regional population.

Total employment for the California Region would increase from 7.1 million in 1965 to a projected 22.4 million in 2020. Increasing employment is projected for the following sectors: Chemical and allied products, paper and allied products, manufacturing, primary metals, textile and mill products, food and kindred, mining, and other.

Total personal income in constant 1958 dollars is projected to increase from slightly more than $56 billion in 1965 to over $725 billion in 2020 for the Region. Per capita income would increase 326 percent over the 55-year projection period, from $3,095 in 1965 to $13,206 in 2020. Per capita income for the Region is expected to remain higher than the United States average throughout the projected period.

Based on OBERS productivity estimates gross regional product was $69 billion in 1965 and projected to be $945 billion in 2020. This is a 4.9 average annual percent increase over the 55-year period.

Base Plan Projections

The Base Plan projections are a regional modification of the OBERS projections. The intraregional distribution of the OBERS population was changed to reflect one regional view of the growth rates anticipated in major subregions. This redistribution results in lower projected levels of economic activity in the southern portions of the Region. Projections of declining levels of migration to the Region and to Southern California were based on the assumption that, to a greater extent, natural increase within each of these areas would provide for the labor demands of a growing economy.

Regional projected population for Base Plan is 54.9 million in 2020, the same as OBERS. The South Coastal Subregion population, however, is 8.1 million less than the OBERS projection.

Base Plan employment and income projections essentially followed the same methodology as that used in deriving the respective OBERS income projections. The same per capita income and per worker earnings figures for the target years were used for both the OBERS and Base Plan projections. In all cases, the Regional totals for the Base Plan and

OBERS projections are approximately the same. There are some slight differences, however, due to changes in the intraregional mix for each projection.

Projected Base Plan total employment for the California Region increases from 7.1 million in 1965 to 22.5 million in 2020. All major sectors show increases in employment. Major differences with OBERS are in the distribution of employment within the Region and the effects of a greater anticipated level of agricultural activity.

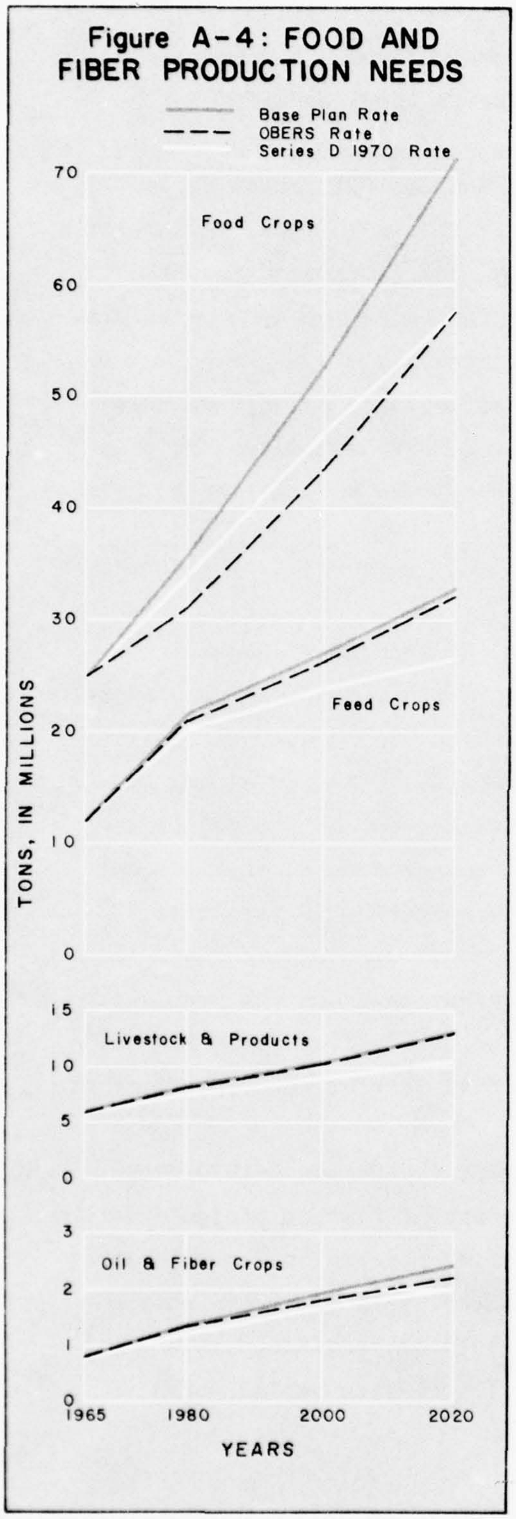
Under the Base Plan assumptions, gross regional product is somewhat greater ($952 billion in 2020) than the OBERS estimate. This is largely because the Base Plan includes 1.2 million more irrigated acres than the OBERS.

Series D-1970 Projections

In January 1970, the California State Department of Finance, basing its data on more recent survey information, released provisional population projections to 2000 for California. The Department of Finance used Series D fertility rates of the U. S. Bureau of the Census. Application of Series D results in an estimated annual population increase for the nation of about 1 percent, compared to the 1.3 percent for Series C. Migration into California was assumed to remain at 200,000 annually from 1974 to 2000.

The California Department of Water Resources based its population projections for Bulletin No. 160-70, "Water for California -- The California Water Plan -- Outlook in 1970",on this work by the Department of Finance.

However, both for that bulletin and for the Series D-1970 projection of the framework studies, the Department of Finance projections were extrapolated to year 2020. To arrive at the regional population projections, the Base Plan projections of the State of Oregon portion of the region were added to the Series D-1970 projections. This gives a projected increase of 141 percent over the 55-year period, or a regional total of 44.8 million in 2020.



Employment projections for Series D-1970 were not derived.

Series D-1970 estimate of total personal income, using the same per capita income as the OBERS and Base Plan projections, increases from $56 billion in 1965 to $592 billion in 2020.

The projected gross regional product is lower for the Series D-1970 than for the OBERS and Base Plan. It increases from $69 billion in 1965 to $770 billion in 2020, an average annual increase of 4.5 percent.

FOOD AND FIBER PRODUCTION NEEDS

Projections of food and fiber needs of the Region are developed for the three levels of economic activity. (Figure A-4) These are based upon estimates of national population, per capita consumption, and manufacturing use and upon export projections. For the Base Plan and OBERS projections, the future needs for feed, oil and fiber, and livestock and products are the same or nearly the same, but the Series D-1970 needs for these components are generally smaller.

Projected needs for food crops to be satisfied by the California Region are considerably higher for Base Plan than for OBERS and Series D-1970. This results from the Base Plan projection assuming a greater regional production of food crops than assigned on a national basis. Percentagewise, the Series D-1970 projection is also higher than OBERS.

PART IV - HISTORIC WATER AND RELATED LAND RESOURCES DEVELOPMENT

In this Region of rainless summers and often remote water sources, the development of land often has depended upon the concomitant development of water.

WATER DEVELOPMENT

Surface water development has progressed through three stages: (1) local diversions from a river, (2) storage of water from a river for use within the river basin, and (3) storage and transport of water from river basins abundant in water to those deficient in water. In areas such as the San Joaquin Valley, the development of electrically powered pumps made possible the utilization of ground water as early as 1900, and postponed for many years the need to store or import surface water. Water development in the Region has not proceeded uniformly. Simple single-purpose works exist near complex multiple-purpose works, which may have been installed at different times and for different purposes under authorities that evolved somewhat independently. Most were developed by public agencies, including the State and Federal Governments, special purpose districts, and cities. Some are owned and operated by mutual water companies and private commercial companies or utilities.

The California Water Plan, and related reports of the California Department of Water Resources, have been published to provide a basic framework for planning to satisfy long-range water demands of that State. Two interbasin developments that help accomplish this general objective are the federal Central Valley Project and the California State Water Project. These projects exemplify the coordinated systems approach to water resource conservation and management. The coordinated operation and extension of the two projects can enable future water service to a number of areas of California where service could not be provided by local or independently operated projects or by other sources.

Construction of the Central Valley Project, which was begun by the U. S. Bureau of Reclamation in 1935, marked the beginning of coordinated interbasin water development in the Central Valley of California. Water service from the Contra Costa Canal, the first unit of the Delta Division, began in 1942. Since that time, the Central Valley Project has been expanded and is now providing water supply, flood protection, electrical energy, recreation, salinity control, assistance to navigation, and an improved environment for fish and wildlife in the Sacramento and San Joaquin Valleys, the Sacramento-San Joaquin Delta, and the San Francisco Bay area. During 1969, deliveries of water totaled almost 6 million acre-feet.

In 1959, the California Legislature enacted the Water Resources Development Bond Act, popularly known as the Burns-Porter Act. This Act, which authorized the sale of bonds for the construction of facilities to assist in developing the water resources of California, was approved by the electorate in 1960. As a result, the California State Water Project, the largest single water development ever carried out in the United States, became a reality. With 99 percent of initial facilities completed or under contract, the State Water Project includes 21 major dams and reservoirs, the 444-mile-long California Aqueduct and other conveyance facilities, 22 pumping plants, and 7 powerplants.

During 1970, some 380,000 acre-feet of project water was delivered to public agencies in the counties of Butte, Plumas, Napa, Santa Clara, Alameda, Stanislaus, Kings, Kern, and Tulare. When in full operation, the State Water Project will supply 4,230,000 acre-feet per year to 31 water service agencies who have signed contracts with the State of California. Other benefits of the Project include salinity control in the Sacramento-San Joaquin Delta, hydroelectric power, flood control, new recreation areas, and the improvement of fish and wildlife habitats.

Over the past 30 years, local water agencies have invested some $4 billion in surface and ground water projects. Although the State

Water Project and the federal Central Valley Project, both of which involve large interbasin transfers of water, are more widely known, the efforts of local agencies have long predominated water development in the Region.

The metropolitan areas of Southern California and the San Francisco Bay area, having developed their nearby water sources, had to tap more distant waters. Los Angeles built the Los Angeles Aqueduct from Owens Valley, and the Metropolitan Water District of Southern California built the Colorado River Aqueduct. These far-flung surface works in Southern California supplement local surface and ground water supplies. To the north, San Francisco brought water from Hetch-Hetchy Valley in the Sierra Nevada and San Francisco Bay cities to the east had brought water from the Mokelumne River. In the Central Valley, storage in foothill and mountain reservoirs developed by local agencies now supplements irrigation systems which began as local valley canals. Often this storage not only conserves water, but controls floods, and generates electric energy. Major examples of such multiple-purpose storage are Lake Almanor on the Feather River, New Don Pedro Reservoir on the Tuolumne River, and Lake McClure on the Merced River.

About 86 percent of the water diverted from streams and pumped from the ground serves to irrigate farmland; about 12 percent, to satisfy municipal and industrial needs; and about 2 percent, to satisfy other needs. Quantities of presently developed water supplies are tabulated in Section B - Part III.

Surface Water

Water developments are designed to cope with winter floods and summer droughts, and to perform through years of high runoff and years of low runoff. Rain and/or snow feed the streams of the Region. The rain-fed streams rise and fall rapidly with winter storms. The snow-fed streams rise in the spring or early summer and fall in the later summer. All streams normally diminish by later summer.

Both single- and multiple-purpose surface reservoirs regulate streamflows. Hundreds of miles of artificial channels, canals, and pipelines convey water from surface streams. Levees and reservoirs provide flood protection both singly and in conjunction with other works. In 1965, hydroelectric powerplants generated about 30 percent of the electrical energy consumed in the Region. Usable surface reservoir capacity approximates 27 million acre-feet. It is distributed among several hundred reservoirs, 49 of which that were operating in 1965 can each store more than 100,000 acre-feet of water. (Figure A-5) These reservoirs can store about 6.0 million acre-feet of water specifically for flood protection during the flood season.

INDEX TO Figure A-5: MAJOR RESERVOIRS* OPERATING IN 1965

Map Reference Number	Dam	Purpose**							Maximum Reservoir				Recreation Land (acres)	Total Flood Control Storage (1,000 acre-feet)	Project	
		C	F	I	M	N	P	R	Storage (1,000 acre-feet)	Elevation (feet)	Shoreline (miles)	Area (acres)			Federal	Other
1	Upper Klamath Lake	-	-	I	-	-	-	-	873	4,143		90,100			X	-
2	Clear Lake	-	F	I	-	-	-	-	527	4,480	65	24,800	7,679	302	X	-
3	Trinity	-	-	I	-	-	P	-	2,448	2,370	145	16,400	25,625	292	X	-
4	Coyote	C	F	-	-	-	-	R	122	765	17	1,956	1,500	48	X	-
5	Nacimiento	C	F	I	M	-	-	R	350	800		5,370		150	-	X
6	Twitchell	-	F	I	-	-	-	-	240	652		3,700		89	X	-
7	Cachuma	-	-	I	M	-	-	-	205	750	42	3,100	300	32	X	-
8	Santa Felicia	C	-	I	M	-	-	-	100	1,055		1,240			-	X
9	Casitas	-	-	I	M	-	-	R	252	567	31	2,700	1,800		X	-
10	Prado	-	F	-	-	-	-	-	217	543		8,850	5,387	217	X	-
11	Lake Mathews	-	-	I	M	-	-	-	182	1,390		2,750			-	X
12	Henshaw	C	-	I	-	-	-	-	204	2,727		6,020			-	X
13	El Capitan	C	-	I	M	-	-	-	116	750		1,580			-	X
14	Shasta	-	F	I	-	N	P	-	4,552	1,065	365	29,500	2,875	1,359	X	-
15	Whiskeytown	-	-	I	-	-	P	R	241	1,210	36	3,200	15,721	35	X	-
16	Lake Almanor	-	-	-	-	-	P	-	1,308	4,500		28,257			-	X
17	Bucks Lake	-	-	I	-	-	P	-	103	5,155		1,827			-	X
18	Black Butte	-	F	I	-	-	-	-	160	473	40	4,600	3,050	232	X	-
19	Clear Lake	C	-	I	-	-	-	-	1,100	1,326		43,800			-	X
20	Camp Far West	C	-	I	-	-	-	R	103	300		2,680			-	X
21	L. L. Anderson	C	-	I	M	-	P	-	134	5,245		1,418		7	-	X
22	Union Valley	C	-	I	M	-	P	-	271	4,870		2,860			-	X
23	Folsom	-	F	I	-	-	P	-	1,010	466	75	11,500	4,875	510	X	-
24	Monticello	-	F	I	M	-	-	R	1,602	440	165	20,700	1,705	300	X	-
25	Salt Springs	-	-	-	-	-	P	-	139	3,958		925			-	X
26	Pardee	-	F	-	M	-	P	-	210	568		2,134		200	-	X
27	Camanche	-	F	-	M	-	-	-	432	235		7,700			-	X
28	New Hogan	C	F	I	-	-	-	R	325	713	50	4,400	1,300	196	X	-
29	Melones	C	-	I	-	-	P	-	112	718		1,843			-	X
30	Don Pedro	C	F	I	-	-	P	-	289	605		3,100		213	-	X
31	Cherry Valley	C	F	-	M	-	P	-	266	4,700		1,765		102	-	X
32	O'Shaughnessy	C	F	-	M	-	P	-	360	3,806		1,960		182	-	X
33	Exchequer	-	-	I	-	-	P	R	289	707		2,720			-	X
34	Friant	-	F	I	-	-	-	-	521	578	43	4,900	1,950	390	X	-
35	Shaver Lake	-	-	-	-	-	P	-	135	5,370		2,177			-	X
36	Mammoth Pool	-	-	-	-	-	P	-	123	3,330		1,100			-	X
37	Vermilion Valley	-	-	-	-	-	P	-	125	7,642		1,890			-	X
38	Courtright	-	-	-	-	-	P	-	123	8,186		1,621			-	X
39	Wishon	-	-	-	-	-	P	-	128	6,539		1,000			-	X
40	Pine Flat	C	F	I	-	-	-	-	1,000	952	67	5,970	6,800	1,113	X	-
41	Terminus	-	F	I	-	-	-	R	150	694	22	1,945	450	258	X	-
42	Isabella	C	F	I	-	-	-	-	570	2,606	38	11,400	2,600	842	X	-
43	Buena Vista	-	-	I	-	-	-	-	205	296		24,000			-	X
44	Lake Tahoe	-	-	I	-	-	P	-	732	6,229		120,000			X	-
45	Long Valley	-	-	-	M	-	P	-	183	6,782		5,280			-	X
46	Parker	-	F	-	M	-	P	-	648	450	200	20,400	1,000	180	X	-
47	Calaveras	C	-	-	M	-	-	-	100	753		1,450			-	X
48	Lower Hell Hole	C	-	I	-	-	P	R	208	4,630		1,250		17	-	X
49	Topaz Lake	C	-	-	-	-	-	-	125	5,006		2,300			-	X

* Reservoirs whose maximum capacity equaled or exceeded 100,000 acre-feet

** C = Conservation N = Navigation
F = Flood Control R = Recreation
I = Irrigation P = Power
M = Municipal & Industrial

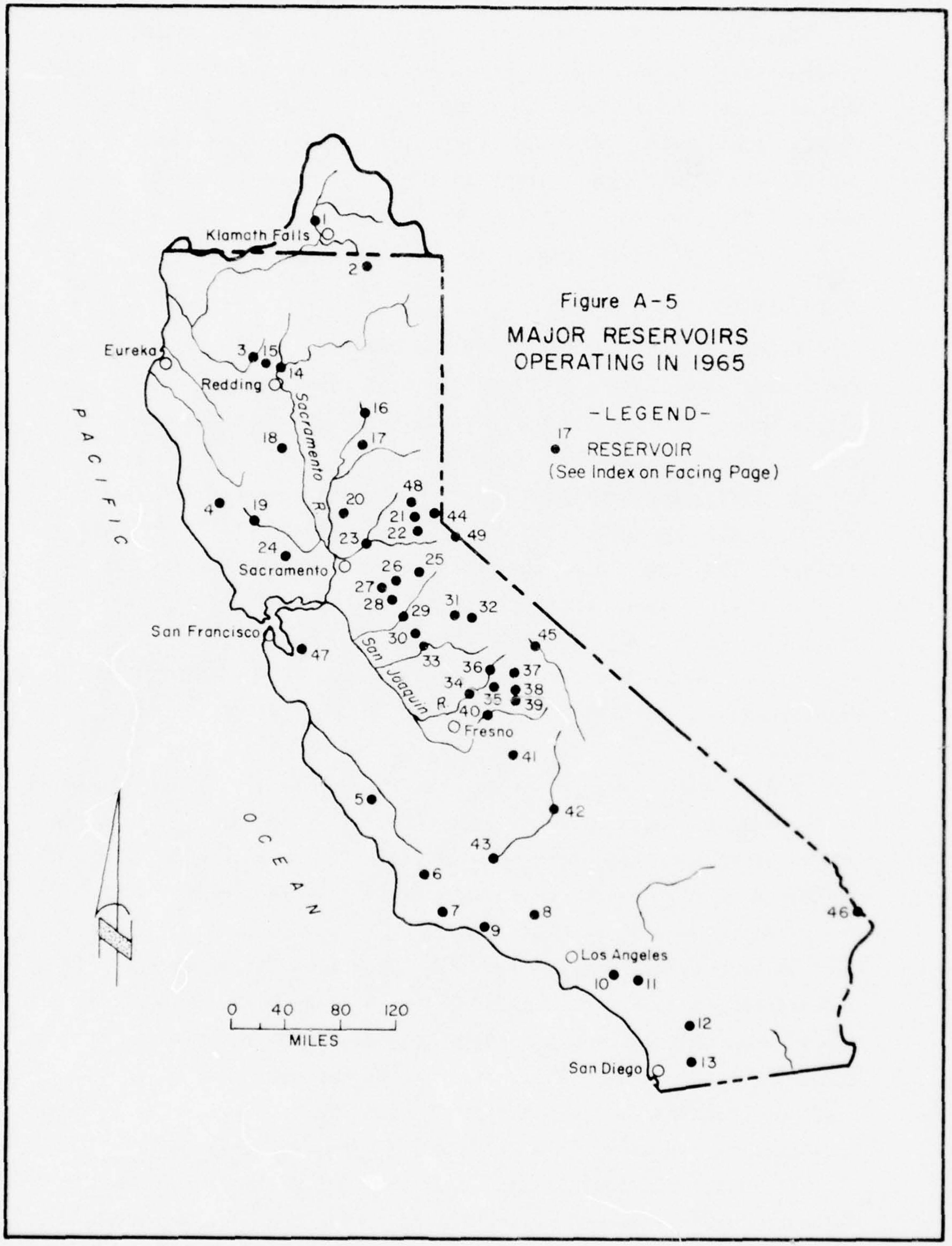


Figure A-5
MAJOR RESERVOIRS
OPERATING IN 1965
-LEGEND-
17
RESERVOIR
(See Index on Facing Page)
Klamath Falls
Eureka
Redding
Sacramento
R.
Sacramento
San Francisco
San Joaquin
R.
Fresno
Los Angeles
San Diego
PACIFIC
OCEAN
0 40 80 120
MILES
1
2
3
4
5
6
7
8
9
10
11
12
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14
15
16
17
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The river systems provide spawning habitat for salmon and other anadromous fish, which return from the ocean to ascend their native streams at spawning time. Cold and warm water streams and reservoirs, canals, tidal channels, lakes and ponds provide spawning habitat for inland fish. This habitat includes more than 29,000 miles of streams, about 8,000 miles of canals, and more than 500,000 surface acres of lakes, ponds, and reservoirs.

Ground Water

Ground waters lie chiefly in the sedimentary fill of more than 250 ground water basins scattered through the Region. Most of the usable ground waters, however, lie in the Sacramento and San Joaquin Valleys, where wells supply extensive irrigation.

In 1965, pumps supplied about 15 million acre-feet of ground water: 2 million for cities and industry, and 13 million for agriculture. The safe annual yield of the ground water basins under 1965 conditions is an estimated 11.5 million acre-feet. Several areas have exceeded this safe yield, notably the southern San Joaquin Valley, the Southern California coastal plain, and the Antelope Valley of Southern California. The result is an overdraft of about 3.5 million acre-feet.

Water pumped from the ground has greatly assisted economic growth in the Region. Much of such water irrigates farmland. It also provides almost half the supply for cities, industries, homes, and livestock. However, overdrafts in many areas have resulted in water deficiency, water quality deterioration, and land subsidence.

In many areas, Californians deliberately use surface water to recharge the ground water basin. They do so by means of modified streambeds, or by flooding recharge basins, pits, ditches and furrows, or by injection wells. The latter method has been used along the coast of Southern California to create a hydraulic barrier to prevent intrusion of sea water into overdrawn ground water basins.

In 1965, Californians used more than 1.5 million acre-feet of water to recharge ground water basins: 900,000 acre-feet in the

San Joaquin Valley, 425,000 acre-feet in the South Coastal Subregion, 145,000 acre-feet in the San Francisco Bay Subregion, and 50,000 acre-feet in the Central Coastal Subregion.

Flood Control

The Region's flood control and flood damage reduction program includes structural and nonstructural measures of federal, state, and local agencies. Structural measures include reservoirs, retardation structures, levees, and channel improvements. Nonstructural measures include watershed treatment, flood forecasting, floodplain zoning, and flood proofing.

The existing flood control program in 1965 provided 5,915,000 acre-feet of flood control capacity in reservoirs and flood detention basins during the critical flood period. In 1965, more than 3,200 miles of levee and 2,900 miles of improved channel served an extensive levee, channel, and bypass system of flood control. In the same year, radio and telephonic devices at more than 400 precipitation and stream gage data collection sites, together with telephoned or teletyped reports from public and private agencies and from cooperating observers, assisted in river and flood forecasts. In 1965, watershed treatment projects protected soil and vegetal cover on about 214,000 acres, thus increasing the water-holding capacity of soils, controlling runoff and reducing debris movement, erosion and sedimentation. The Federal Flood Plain Management Services Program provided flood hazard information to federal, state, and local governmental agencies. Such information guides proposals for future land development, suggests needs for land use regulation to avoid future flood damage, and assures that federal agencies will recognize the flood hazards associated with floodplain development.

In both California and Oregon, the counties bear the responsibility of regulating land use and of zoning floodplains. Twenty-four counties in California regulate floodplains in some way. Of these, eight use floodplain zoning to regulate development. Existing flood

control measures prevented more than $270 million in damages during the December 1955 flood. Nine years later, existing measures prevented more than $340 million in damages.

Navigation

The chief navigable waters of the Region include the bays, estuaries, and coastal waters of the Pacific Ocean to the west, the Lower Colorado River to the southeast, and the streams and sloughs of the lower Sacramento and San Joaquin River systems.

In 1965, ports and waterways of the Region handled almost 100 million tons of waterborne commerce -- 8 percent of the total for the United States. Petroleum and its products comprised almost three quarters of the regional total. Metals, chemicals, lumber, and agricultural products contributed significantly to the remainder. In 1965, about 25 percent of the recreational boating in the Region was on its navigable waters.

The port complexes of San Francisco Bay and Los Angeles-Long Beach Harbors handle most of the waterborne commerce in the Region.

Much of the remaining commerce passes through the harbors at Humboldt Bay and Crescent City in the North Coastal Subregion; at Port Hueneme and San Diego in the South Coastal Subregion; and at Stockton and Sacramento in the Delta-Central Sierra Subregion. The Federal Government has dredged channels, built breakwaters and other works, or has authorized similar projects at all of these ports. Privately owned petroleum terminals lie offshore the Central and South Coastal Subregions.

Existing commercial navigation facilities include 190 miles of channels and 820 acres of anchorage areas and basins with depths of 30 to 50 feet; 24 miles of protective breakwaters and jetties; and terminal facilities at 320 wharves and on 3,600 acres devoted to handling cargo. The Federal Government has authorized a minimum release of 4,000 cubic feet per second from Shasta Dam so as to maintain navigable depths in the Sacramento River. However, releases for other purposes generally maintain this minimum flow.

Recreational boats and related facilities concentrate heavily in San Francisco Bay and along the San Francisco and Los Angeles coastlines. Harbors and marinas for small craft, launching ramps for trailered boats, and moorings for transient boats cluster in these areas. The lack of a chain of harbors of refuge along the coast severely constrains boating on the coastal waters and, particularly, intercoastal cruising.

Some of the major federal small craft projects are at Marina del Rey, Redondo Beach, King Harbor, Mission Bay Harbor, and Oceanside Harbor, all in the South Coastal Subregion. The recreational fleet also berths at federal, state, county, city or private marinas along the coast, in San Francisco Bay, or along the Sacramento, San Joaquin, or Colorado Rivers. In 1965, the Region provided 7,900 moorings for transient boats and could have used an additional 1,300 moorings. It provided 41,200 berths for small craft and could have used an additional 10,300 berths. It provided 760 launching lanes and hoists to handle trailered boats.

LAND DEVELOPMENT

In 1965, 52 percent of the Region's land was privately owned. Private ownership included nearly all the land suited for intensive agriculture as well as nearly all that suited for urban and industrial development. It also included about 50 percent of the land suited for timber production and about 62 percent of that suited for grazing.

In 1965, 44 percent of the Region's land was federally owned. The Forest Service administers 44 percent of this land -- the national forsts, lying generally in the mountainous areas of the Region. The Bureau of Land Management administers 37 percent of the federal land, most of which lies in mountain foothills and deserts. The National Park Service administers an additional 9 percent, which includes parks in desert, seashore, foothill, and high-mountain areas. The Department of Defense administers 6 percent of the land, mostly desert. In addition, the Department of Defense,

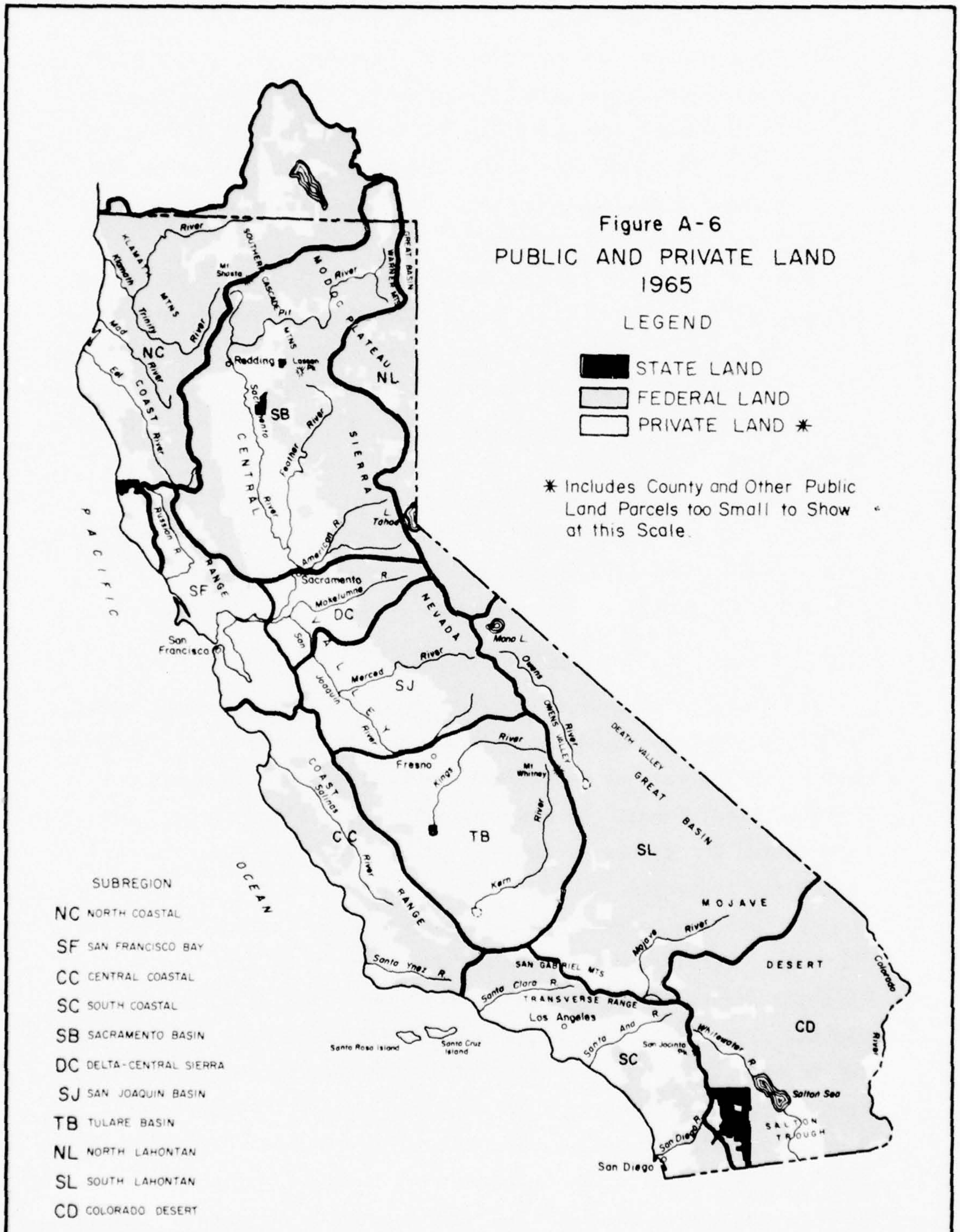
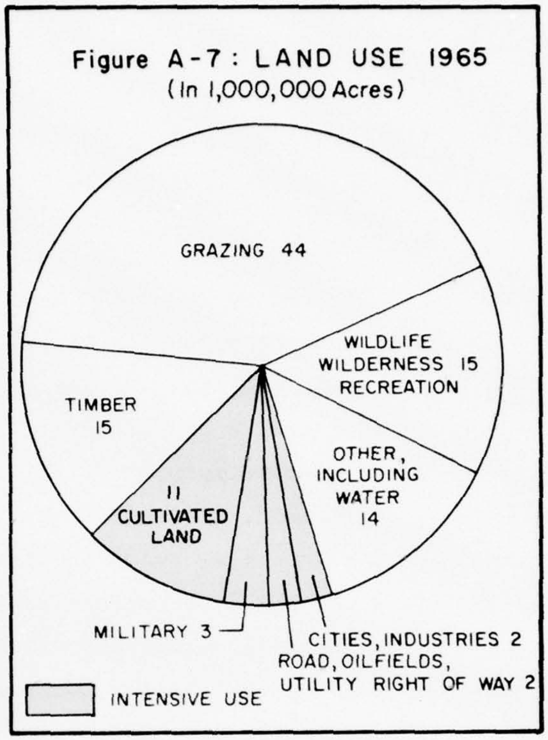


Figure A-6
PUBLIC AND PRIVATE LAND
1965

the Bureau of Reclamation, the Fish and Wildlife Service, the California Department of Fish and Game, and the Oregon State Game Commission possess secondary administrative responsibilities on lands for which primary jurisdiction lies with other federal agencies.



In 1965, 2 percent of the Region's land was state owned. The final 2 percent of the land was owned by cities and counties, mostly in parks and roads, and by school, water, and irrigation districts. Figure A-6 depicts the general distribution of public and private lands in the Region.

In comparison to total acreage, that acreage developed for intensive use after a hundred years of settlement in the Region is quite small. Cities occupy 2 percent of the Region; roads, oil fields, and utility rights-of-way, another 2 percent; military bases, 3 percent; and cultivated land, 11 percent -- most of which is irrigated. Together, these uses occupy only 18 percent of the Region. (Figure A-7)

Most of the regional lands, including even cities and deserts, support some sort of wildlife. The floodplains, always attractive to mankind, have been the first lands settled and developed. And, although they have witnessed many disastrous floods, the developments continue to increase.

The present pattern of land ownership and administration in part reflects land grants by the Spaniards and Mexicans before California became a State. It also reflects past policies of the Federal Government in its efforts to settle the West -- the Homestead, Timber, and

Stone Acts, mining laws, and land grants to states, railroads, and individuals, effectively lured people and industry to the West.

Although major transfers of land ownership occurred during the nineteenth and early twentieth centuries, exchanges of public and private lands continue into the present.

Shoreline

Including the 280 miles of shoreline which encloses San Francisco Bay, and the almost 400 miles which circle 8 Channel Islands, the ocean shoreline of the Region extends more than 1,740 miles. Three-quarters of the people in the Region live within an hour's drive of some portion of this shoreline.

In 1965, cities, farms, and forests occupied about 1,000 miles of the shoreline zone, a strip of land about 500 feet wide which includes the land subject to sea erosion. Harbors, military, and other areas occupied the remaining regional shoreline. About 600 miles of shoreline lay under public control, about half of it by the Federal Government.

In 1965, about 300 miles of publicly controlled area was open to recreation -- one-third of it to scenic shoreline, another third to swimming beaches, and a final third to public beaches too cold, too dangerous, or too rocky for swimming. Most of the latter beaches lay along the northern coast and were subject to unfavorable exposure as well as to unfavorable climate. Most of the swimming beaches lay along the southern coast of the Region.

The desire to swim and sunbathe attracted most visitors to the shoreline. In addition to swimmers and sunbathers, however, the shoreline areas accommodated surfers, scuba divers, free divers, fishermen, shellfishing enthusiasts, picnickers, campers, driftwood collectors, rock collectors, walkers, wildlife watchers, tide pool explorers, and motorists.

In 1965, swimming along the shoreline accounted for an estimated 53 million recreation-days of use. Shoreline fishing accounted for approximately 4 million recreation-days of use, and other activities

accounted for an estimated additional 13 million recreation days of use.

Measures taken to fight shore erosion include artificially widened protective beaches, stabilizing groins, revetments, seawalls, offshore breakwaters and sand bypassing and sand replenishment systems. By 1965, the Federal Government had built 11 miles of stabilization works and 1 mile of seawall, and had replenished 14 miles of beach. All but 1 mile of these works lay in the South Coastal Subregion. Considerable beach protection work had also been done by state, county, and city agencies. For the most part, private measures taken for shoreline protection were temporary.

Minerals

Of the $1.6 billion in minerals produced in the Region in 1965, mineral fuels represented about 64 percent; nonmetals, 32 percent; and metals, 4 percent. Although the value of mineral output is low in comparison to the total regional product, mines provide basic raw materials for other industrial and trade activities. Petroleum and natural gas provide most of the energy needed to manufacture and transport goods, supply homes, pump municipal and agricultural water supplies, and dispose of waste waters. Cement, sand, and gravel provide material for the buildings and roads required by the Region's 18 million people.

Irrigation and Drainage

In 1965, the Region's 8,765,000 acres of irrigated crops were grown on a net area of 8,435,000 acres. The 330,000 acres, by which crops exceeded irrigated land, represented double cropping. Production of these crops required delivery of 29,780,000 acre-feet of water to farm headgates. Pasture accounted for 1,551,000 acres -- 18 percent -- of the irrigated acreage. Alfalfa accounted for 1,415,000 acres; deciduous, vineyard, and subtropical crops, for 1,207,000 acres; miscellaneous truck crops, for 907,000 acres; miscellaneous field crops, for 849,000 acres; hay and grain, for 843,000 acres;

cotton, for 740,000 acres; and rice, sugar beets, and citrus, for 923,000 acres.

Surface storage reservoirs and ground water basically provide most of the water used to irrigate crops in the Region, although minor diversions directly from unregulated streams are numerous. More than 260 public water districts in the Region provide water to more than half the irrigated acreage.

Much of the land under irrigation in the Region must be artificially drained to maintain its productivity. Depending upon soils, topography, climate, and crops, drainage requirements and methods appropriate to accomplish drainage vary considerably. The major methods in use are surface drainage ditches, tile drains, and ground water pumping. Extensive drainage works are in use in the Central Valley, particularly in the low-lying areas near the trough of the valley and in the Sacramento-San Joaquin Delta. The Imperial Valley has some of the Region's most severe drainage requirements, both because of the salinity and texture of its soils and because of the salinity of its Colorado River water supply. In the last 40 years alone, over 350,000 acres in the Imperial Irrigation District received tile drainage treatment.

Recreation

California residents seek 70 percent of their recreation within a one-hour travel radius from their homes.

Most nonurban recreation occurs at national, state, and county parks, at developed recreation areas on the public domain, at wildlife refuges, on military lands, at historic sites and at private resorts generally close to inland or ocean waters. The Region contains 13 national parks and 22 national forests.

Fish and Wildlife

The Region provides a wide range of biotic communities both on its public and private lands and in its waters. Millions of waterfowl cross the Region along its Pacific Flyway. Ten million

waterfowl have been known to winter in the Region at waterfowl areas lying along the coast and within interior valleys from the Klamath Basin to the Salton Sea.

Game is widely distributed. In 1965, hunters provided almost 10 million hunter-days of use within the Region. Forty-seven percent of this time was spent in pursuit of upland game; 38 percent, in hunting big game; and 15 percent, in seeking waterfowl. Nature studies, wildlife photography, and bird watching occupied more than 14 million days of use.

Fishermen provided about 24 million angler-days of use, almost 80 percent of which occurred in inland waters; and the remainder, in bays and the ocean. Inland fishermen sought trout, striped bass, sturgeon, salmon, steelhead, shad, and warm-water fish. Bay and ocean fishermen also sought bass, cod, sturgeon, salmon, steelhead, shad, and other species.

Twenty-five state and federal fish hatcheries operated in 1965, together with seven research stations and laboratories. State and federal fish and game agencies operated 33 wildlife management areas. Many of these permitted the hunting of waterfowl. Others provided winter range for big game and year-round habitat for upland game. Public fish and game agencies owned or operated 392,000 acres of wildlife areas. Public agencies managed wildlife on 426,000 acres of military land. Miscellaneous refuges established by legislative action occupied about 4,500,000 acres. The largest of such refuges, occupying 3.6 million acres, provided protection for the wild burro.

Private hunting clubs are popular in the Region and in 1965, there were about 1,000 waterfowl clubs controlling over 300,000 acres of land. There are also about 190 private pheasant clubs operating on about 165,000 acres of land.

Commercial fishermen in 1965 landed 453 million pounds of fish. This catch has been valued at $50 million. About a fourth was taken from bay and inshore marine areas; the rest, from the sea.

In 1965, the catch of trapped fur animals in California was valued at more than $100,000.

Water supply requirements for lake and fish hatchery operations were 8,800 acre-feet in 1965, while those for wildlife purposes amounted to about 690,000 acre-feet, most of which was consumptive use in waterfowl areas.

Electric Power

The principal industrial developments of the Region lie where sources of energy are readily available. Thus, major industries center in both the Los Angeles and the San Francisco Bay area. Improvements in transportation of coal, oil, and gas will make future locations much more flexible than those of the past. At present, the high cost of transporting both coal and coke has restricted their use in the Region.

The structure of energy supply in the Region contrasts with that in other major regions of the United States. Petroleum and natural gas have provided the basic energy for this Region as compared with water power for the Northwest; natural gas, for the Southwest; and coal, for the remainder of the country.

In 1965, the Region possessed an installed electrical generating capacity of 21,480 megawatts and produced about 96 billion kilowatt hours. Of this total energy production, natural gas provided 59 percent:oil, 17 percent; hydroelectric plants, 23.5 percent; and nuclear fuel, .5 percent.

A 230-kilovolt grid, passing generally from north to south, transported most of the energy. The lines extending from this grid ranged in capacity from 11 to 287 kilovolts. In 1965, transmission lines of 115 kilovolts and more required estimated rights-of-way totaling 192,000 acres.

Power imports to the Region in 1965, for use in Southern California, supplied 1,209 megawatts of peak demand and about 3,000 million kilowatt hours of energy, and they came primarily from Hoover, Parker, and Davis Powerplants on the Colorado River.

Minor amounts, including 156 megawatts of peak electrical power and 810 million kilowatt hours, were exported from the Region in 1965.

PART V - OUTLOOK FOR THE FUTURE

The population and economic growth projected for the Region will create a steady increase in the need for goods and services. Translation of these needs into requirements for water and related land resources from 1965 through 2020 were the principal findings of the framework study. Identification and description of general programs and alternatives, including a project development plan, all aimed at satisfying the requirements and solving the projected problems, were considered to be principle conclusions of the study. Recommendations that will lead to implementation of these programs are contained in the plan of action, located in Section B - Part VII.

FINDINGS

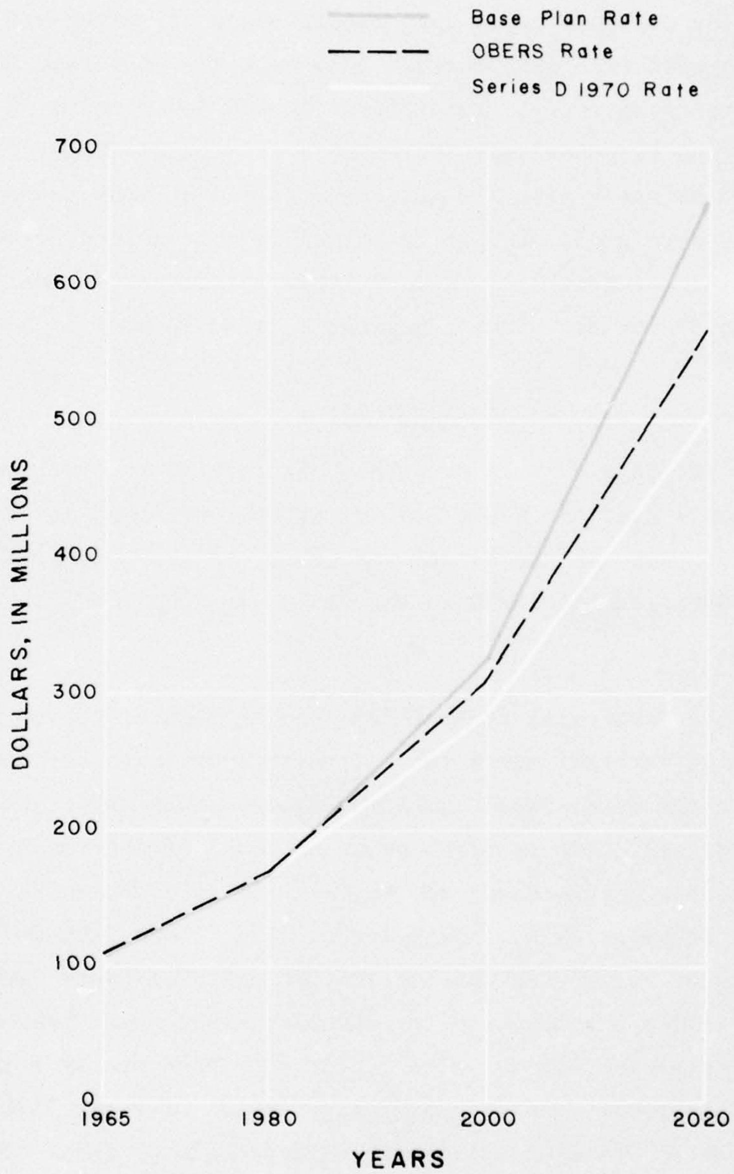
The findings of this study are all related to development of the Region's land and water resources; however, they are presented generally under the functional topics of the several appendix reports. Requirements for land and water were combined.

Flood Control

In the California Region, floodplains generally have been the first lands settled. As a result, these lands have been the scenes of many flood disasters. Subsiding floods often have left damage, suffering, and death in areas shown on Map 2 of Section B.

Recent widespread and destructive floods occurred in December 1955 and December 1964. The December 1955 floods exceeded most maximum flows of record for coastal streams north of Santa Barbara, for Central Valley streams, and for streams in the North Lahontan and in North Coastal Subregions. The floods inundated nearly 1 million acres, killed 64 persons, and left property damages of about $170 million. The December 1964 floods left property damages of about $200 million. These floods struck the North Coastal and Sacramento Basin Subregions, left thousands homeless, and killed 24 persons.

Figure A-8: FLOOD DAMAGE*



* 1965 Price Levels and 1965 Flood Control Measures Without Additional Flood Control Measures.

The residual average annual flood damage under 1965 conditions was about $107 million. Average annual flood damages estimated for 1980, 2000, and 2020 (Figure A-8) illustrate the magnitude of the need for a future comprehensive flood damage prevention program. As shown in Figure A-9, this should include land use regulations and other nonstructural measures as well as flood control and prevention measures.

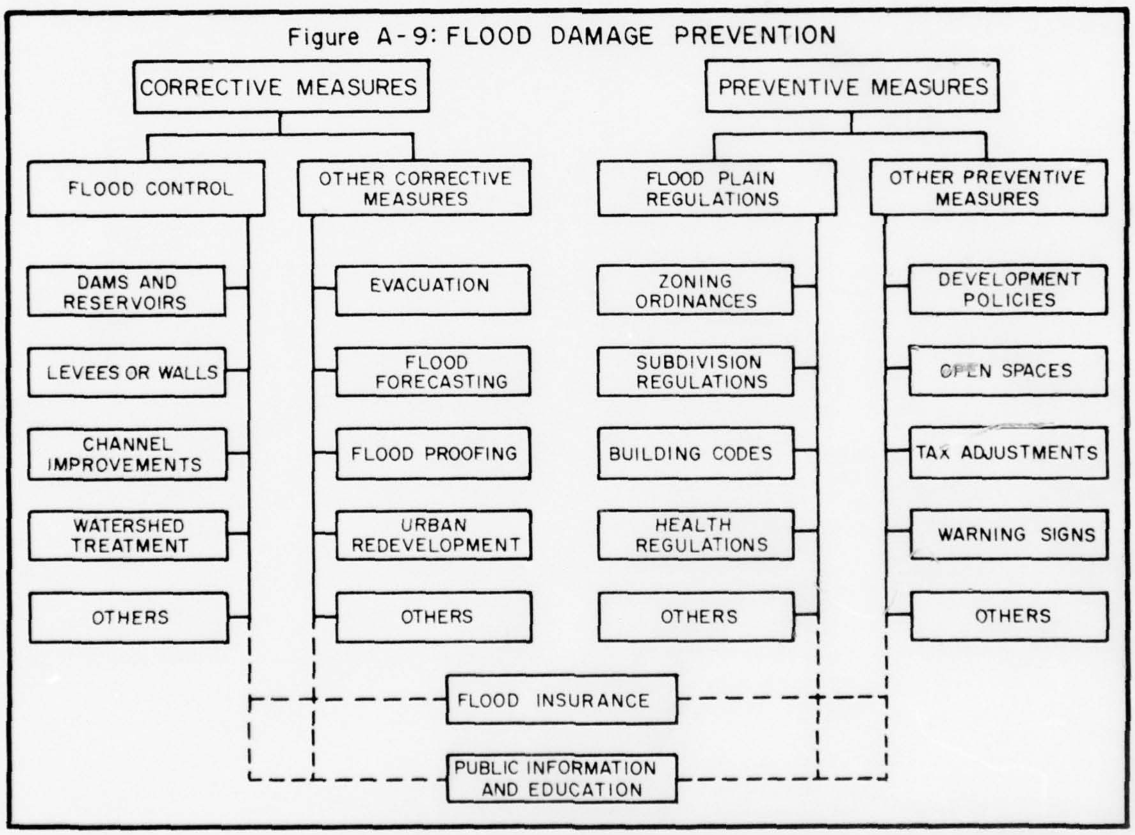


Table A-1 shows the estimated distribution of damages among agriculture; residential and commercial developments; industries; and forest and range facilities for the years 1965 and 2020 under the 1965 level of protection.

TABLE A-1

FLOOD DAMAGE DISTRIBUTION
IN 1965 AND 2020
(percent)

Category	1965	2020
Agriculture	39	13
Residential and commercial developments	25	44
Industries, utilities, and public facilities	25	40
Forest and range resources and facilities	11	3
	100	100

Watershed Management

Problems of watershed management include those of erosion, sedimentation, flooding, and wildfire. Vegetative management measures to reduce water use and increase snow accumulation tend to increase runoff and water yields and in some areas might improve water quality.

In 1965 more than 84 million acres within the Region possessed the potential for moderate or severe erosion. An estimated 41,600,000 acres were eroding at a moderate or severe rate. Specific watershed management programs aimed at erosion control could alleviate the problem of severe erosion on 7,200,000 of these acres. Proper management of croplands, forage, and timber production could alleviate such problems on the remaining acreage (Map 3 in Section B).

Unless additional fire prevention and suppression programs are provided for 64 million acres, wildfire damage in 2020 will exceed that of 1965 by 250 percent.

Shoreline

Critical erosion threatens about 280 of the 1,140 shoreline miles in the Region that are actively eroding (Map 2 in Section B). More than 60 percent of the threatened areas lie in the South Coastal Subregion, most of them adjacent to homes, highways and railroads, or along popular swimming beaches. In 1965, average annual erosion damages reached an estimated $9,900,000. Measures which can be taken to fight such erosion include artificially widened protective beaches, stabilizing groins, revetments, seawalls, offshore breakwaters and sand bypassing and sand replenishment systems.

Erosion damages in 2020 will be almost five times greater than those of 1965 as shown in Figure A-10.

In 1965, public beaches and scenic shoreline proved generally adequate to meet regional needs, although some beaches near large cities proved deficient and urban encroachment threatened some reaches of scenic shoreline.

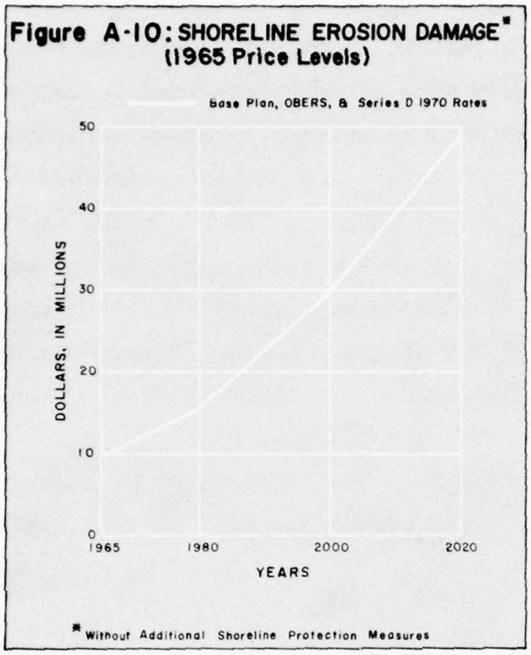


Figure A-11 presents projected needs for public recreational shoreline which, by 2020, are estimated to increase between 2½ and 4½ times the 1965 value for the three projections.

Shoreline requirements of conserving and preserving the unique, scenic, and other values of the coastal environment identified by federal and state agencies are considered a requisite for future public acquisition.

Corollary improvements, primarily access, parking, and adjacent upland camping areas, are needed to permit optimum use of existing and future swimming beaches. Requirements at other nonswimming beaches for fishing, picnicking, tide-pool exploration, nature study, and other activities also require improved access to existing publicly owned nonswimming beaches.

Water Quality

Because many of the northern streams of the Region flow copiously and perennially, and because most of the southern streams flow only intermittently, varied techniques of waste water disposal are practiced. In the south, far more frequently than in the north, waste water is used to recharge ground water basins lying beneath floodplains and dry river beds. In the north, such waste water is often discharged into rivers.

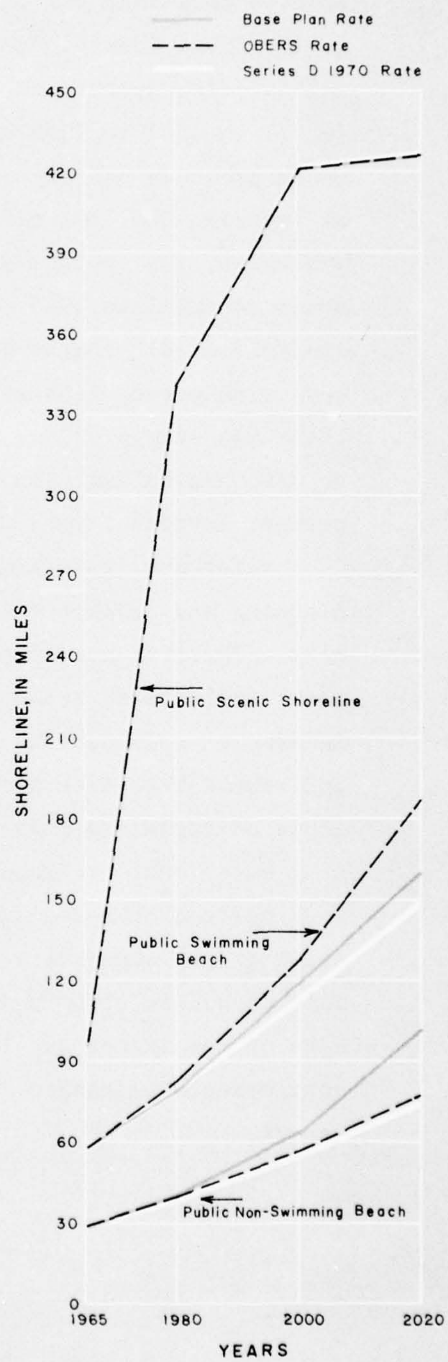
Problems of pollution from sewage occur when there are unwise or improper waste discharges from cities, industries, and farms.

Waste thermal waters from steam electric powerplants can also create difficulties if not properly managed. Areas with major water quality problems are shown on Map 3 and described in Table 3 of Section B.

The mineral quality of most of the Region's waters is adequate for most uses. Although reservoirs have altered the relationship between low, average and floodflows throughout much of the Region, the most dramatic alterations have occurred in the Central Valley and in the Colorado River. In some cases, releases from such reservoirs sustain higher base flows. In other cases, the reservoirs have increased the frequency of low flows and thus have affected adversely the ability of a given stream to absorb waste water to the degree necessary. This ability varies not only as a function of flow, but also as a function of locale and of intended water use. That quantity and concentration of waste constituents which would harm Lake Tahoe would affect the Salinas or the San Joaquin Rivers only insignificantly.

An important exception to the adequacy of the quality of the

Figure A-11
SHORELINE RECREATION NEEDS



Region's waters is the high concentration of salinity in the Colorado River. This is the source of supply for about 75 percent of the water needs of Southern California today and by the year 2000 it will still provide more than half. At Parker Dam, from which water is diverted to the South Coastal Subregion, the average annual concentrations of salinity is expected to increase from about 730 milligrams per liter (mg/l) in 1965 to 1140 mg/l in 2000 as further development of the Basin proceeds and if preventative measures are not taken. Similarly, at Imperial Dam, the diversion point for most of the Colorado Desert Subregion, the average annual salinity is projected to increase from about 840 mg/l in 1965 to about 1290 mg/l in 2000. A basinwide salinity control program by the Bureau of Reclamation is getting under way, with strong support of the Environmental Protection Agency and the seven states of the Colorado River Basin. Its objective will be to maintain salinity in the lower main stem of the River at or below present levels.

Water quality standards in other areas are needed to provide planning and development guidelines to protect the aquatic environment. There is need for timely expansion and improvement of waste water collection, treatment, disposal and management systems. There is also an accompanying need for waste water reclamation facilities and research to determine the long-term effects on humans of direct reuse of reclaimed municipal waste water.

Water quality planning and management studies are needed for many parts of the Region, and agencies to design, construct, and operate comprehensive water pollution and water quality control systems should be created in several key areas. Also, increased knowledge of the impact and fate of pollutants in marine and estuarine environments is needed in order to properly protect the coastal waters.

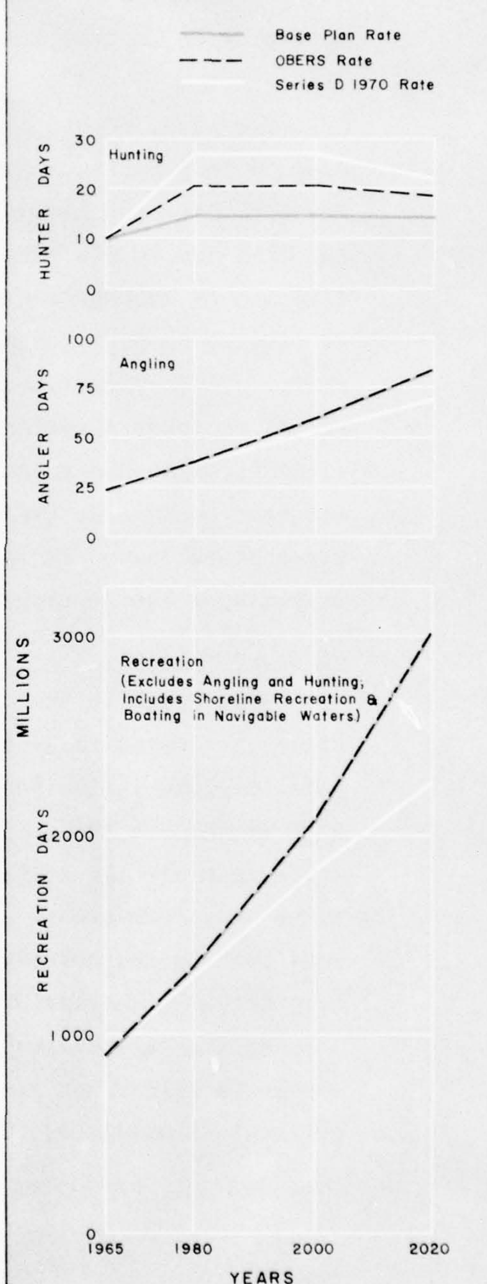
Recreation

The demand for outdoor recreational facilities in 2020 will be three times that of 1965 (Figure A-12). By 2020, for example, the Region will need an additional 187,000 acres of flatwater surface, most of it as close to major cities as possible.

Unmet needs will grow. Almost 95 percent of the unmet needs for outdoor recreational facilities in 1965 was for city parks and playgrounds. The local and state governments that must meet such needs probably will continue to be least financially able to do so. Thus, all levels of government must coordinate their efforts so as to gain the recreational goals of each level.

Preservation of wilderness, open spaces, and historical and archeological sites must be emphasized. Already, growing cities, impounded waters, and channelization have altered many stream reaches. Developments proposed for many of the remaining reaches would alter them also. Furthermore, the number of campers and off-road vehicles will increase.

Figure A-12: RECREATION NEEDS



Thus, natural areas will not remain available for future generations unless the Region rates its social and environmental values equally with its economic values. It must limit the recreational uses in wilderness areas to activities which will not harm those areas. It must provide facilities in developed areas to accommodate all forms of recreation.

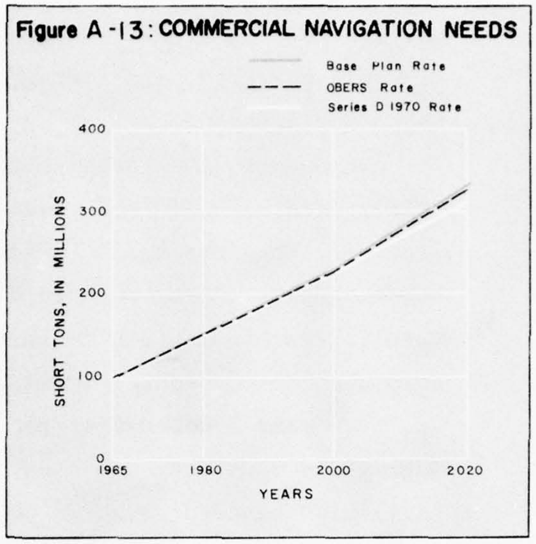
The wild, scenic and recreational values of rivers must be considered in planning. One river in the Region, the Middle Fork of the Feather, has been classified as a wild river under Public Law 90-542, the Wild and Scenic Rivers Act. This federal law applies only to rivers that have national significance. The framework study lists 24 rivers, or portions of rivers, that have potential for such classification. In addition, 13 rivers have been listed as streams of regional or local significance. The former group may qualify for classification under the federal law (six of them have been designated for study under the law); the latter group may qualify for protection under state laws. In either event, classification would have a major impact upon the development of surface water supplies.

Fish and Wildlife

Time spent in hunting and fishing in 2020 will be about three times that spent in 1965 (Figure A-12). Single-purpose fish and wildlife programs in the Region will require about 25 percent more land in 2020 than in 1965. Consumptive uses of water for such programs would increase about one million acre-feet. Most of this water would serve waterfowl areas, and the estimate does not include nonconsumptive uses such as the quantities needed for fish hatcheries and to maintain stream fisheries or natural marsh and riparian vegetation.

As the Region develops, it must carefully weigh the need to preserve its wilderness and estuarine areas, as these support many forms of fish and wildlife. It particularly must preserve its endangered

species, whose present prospects for survival are jeopardized;and its rare species, whose numbers are few throughout their habitats. In 1968, the U. S. Bureau of Sports Fisheries and Wildlife listed 26 species in the Region as endangered and 10 species as rare.



Commercial Navigation

Commercial ships moving through coastal and inland ports play an increasingly important role in the growth of the California Region. In 1967, exports and imports amounted to five billion dollars.

Commercial navigation needs are reported in tons of waterborne commerce.

Petroleum and petroleum products will represent an estimated 60 percent of such commerce by 2020. Foreign commerce, particularly imports, will grow considerably.

Figure A-13 projects the needs for waterborne commerce. Although both Base Plan and OBERS projections correspond regionwide, the OBERS projections would result in about 7.6 million more tons of cargo moving through the Los Angeles-Long Beach harbors in the South Coastal Subregion by the year 2020. This increase would be offset by a corresponding decrease in waterborne commerce at ports in the San Francisco Bay and Delta-Central Sierra Subregions.

As a result of radical changes in vessel design and cargo-handling techniques, many existing waterways and port facilities are obsolescent. To retain competitive status with other world ports

and to meet the requirements of extreme-draft petroleum tankers, dry-bulk carriers, and container-ships, port facilities must undergo major modification.

To accommodate larger ships, existing channels and basins must be deepened, and, in some instances, lengthened; land areas must be expanded; the investment in terminal and transfer facilities must be substantially increased. Specialized bulk-loading and container-handling terminals require far greater acreages of backup land per ship than do the conventional break-bulk, general-cargo wharves.

The port complexes of the San Francisco Bay and South Coastal Subregions must bear the brunt of the growing needs. Together these facilities handled about 80 percent of the Region's waterborne commerce in 1965. They are expected to handle more than 90 percent in 2020.

Recreational Navigation

Increases in population, leisure time, and disposable income have resulted in increases in the number of shallow draft boats. The future needs of recreational navigation are assessed in terms of permanent berthing, transient moorings and launching lanes required to accommodate projected shallow draft boat populations.

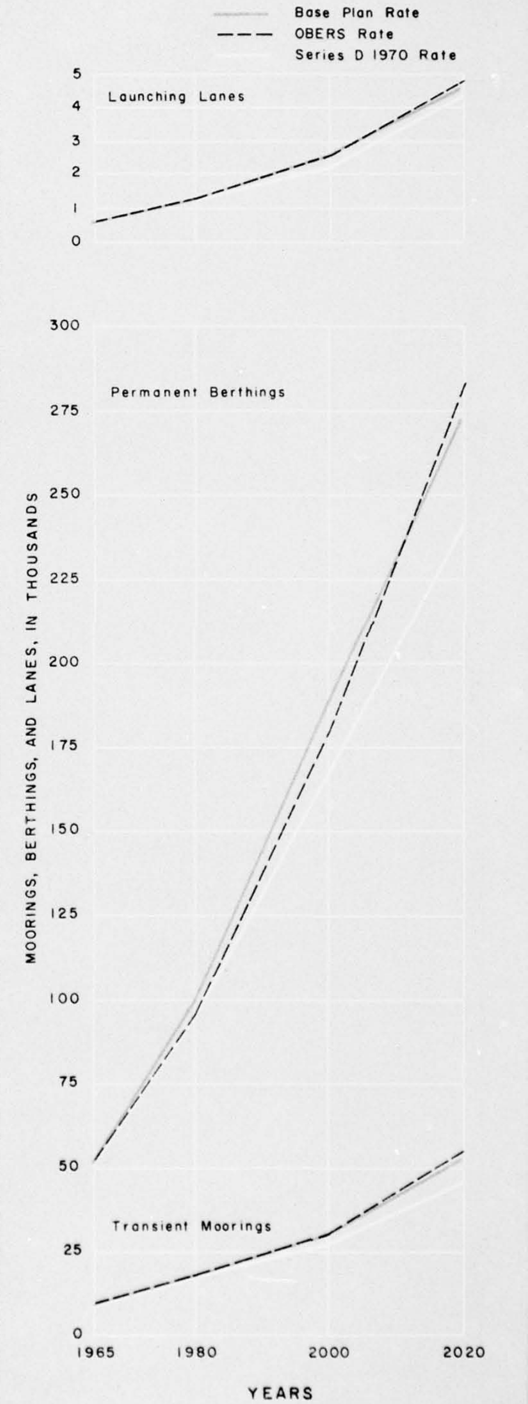
Transient moorings would require all-weather protection and necessary support facilities within harbors of refuge or multiple-purpose harbors. The needed coastal harbors of refuge would provide new boating destinations, encourage cruising, and open presently underused fishing grounds to recreational fishing.

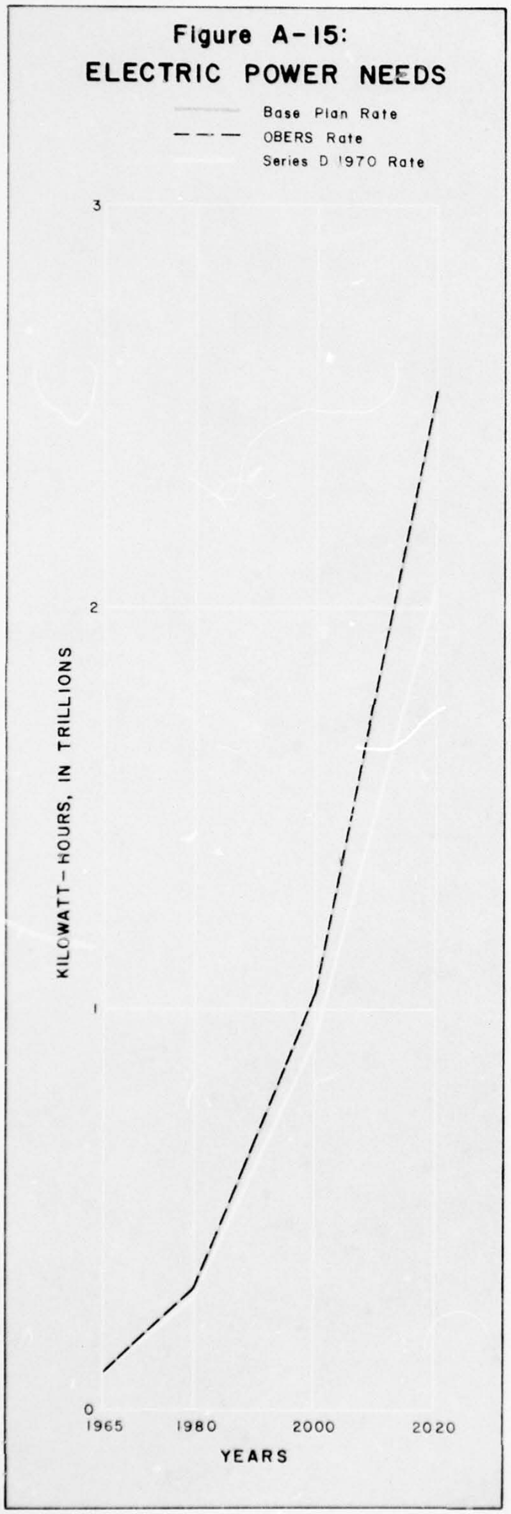
Figure A-14 summarizes the recreational boating needs which in 2020 are expected to be five times the number of berths, five-and-a-half times the transient moorings, and about seven times the launching lanes, available in 1965.

Electric Power

The Region's need for electric power in 2020 will be 20 to 25 times that in 1965 (Figure A-15). Hydroelectric powerplants will provide only about 3 percent of the electricity consumed, although their capacity will have doubled. Steam electric plants, many using nuclear fuels, will produce the remaining electricity. Powerplants will require about 36,000 acres of land. Transmission lines with voltages of 500 kilovolts or more will require 229,000 acres; lower voltage networks will require additional acreage. Freshwater consumption will increase from about 25,000 acre-feet in 1965 to about 80,000 acre-feet in 2020, assuming that most of the large amounts of cooling water required for steam-electric plants would be available at seashore sites. Construction at such sites will involve problems of land use and water temperature. Legal and institutional problems of site regulation and licensing will

Figure A-14:
RECREATIONAL NAVIGATION NEEDS





increase. Site selection to minimize environmental problems either along the seashore or inland will probably become increasingly complex as citizen groups take more active roles in the selection process.

Land and Water

Figures A-16 and A-17 show the expected increase in requirements for land and water.

Needs for urban and industrial land will more than double between 1965 and 2020. Irrigated cropland will increase and nonirrigated cropland will decrease. These cropland estimates are based on the assumption that yields per acre per crop will increase by 27 to 140 percent between 1965 and 2020. This amounts to an average increase of 81 percent.

Net increases in land requirements for new irrigated crops range from 660,000 acres (Series D-1970) to 2.5 million acres (Base Plan). Even with the Base Plan requirements there will still be nearly 10 million additional acres of

FIGURE A-16
LAND REQUIREMENTS

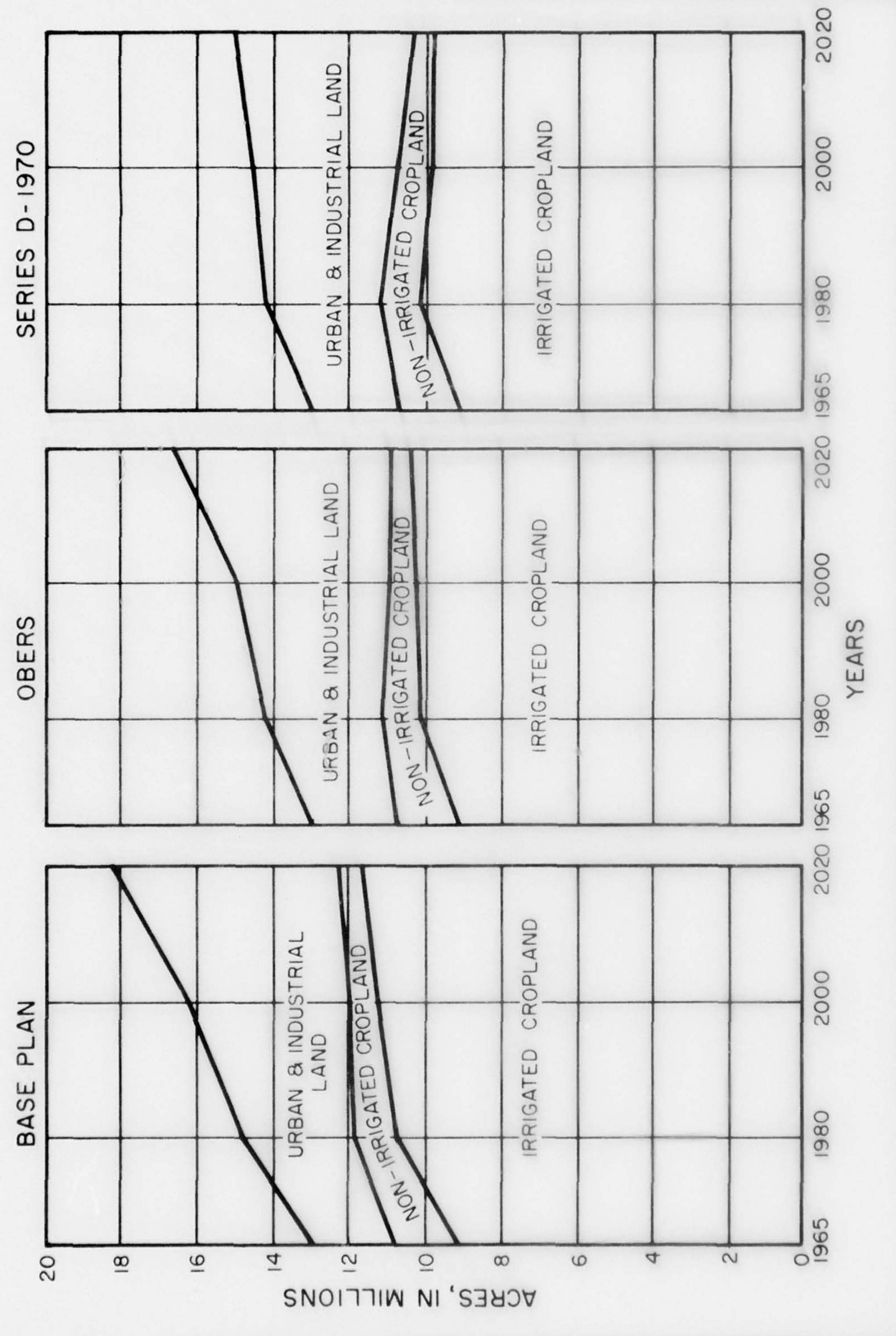
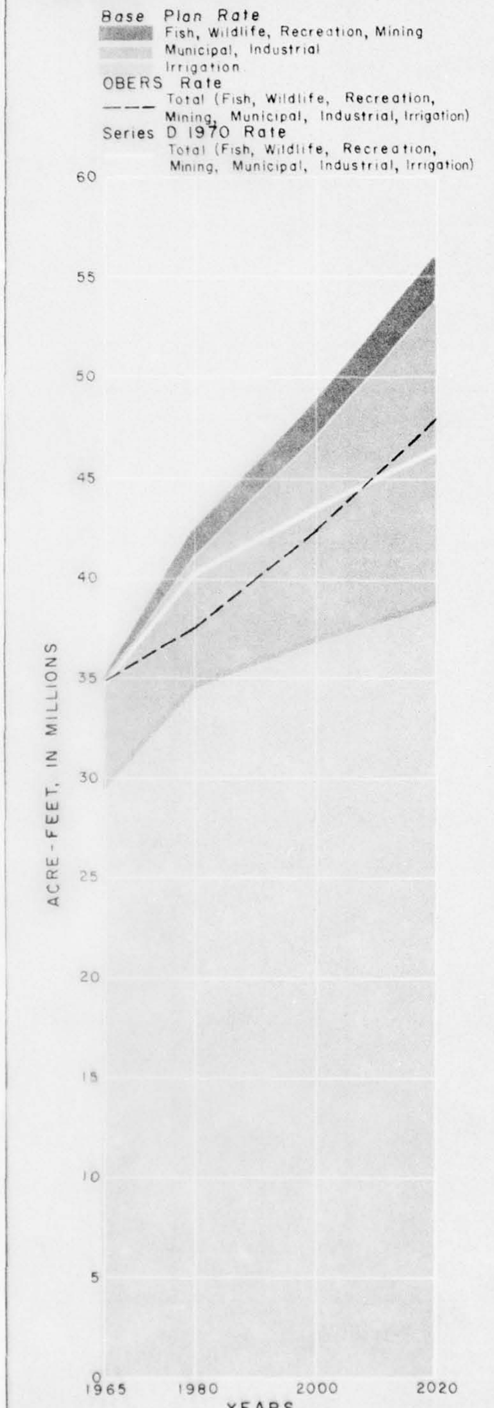


Figure A-17
APPLIED WATER REQUIREMENTS



land that are suitable and available for irrigation development in the Region. In addition to the above, more than 350,000 acres must be developed for irrigation to replace the land currently irrigated which will be lost to urban development. Land supplies for all other functions are adequate except that grazing will continue to supply smaller proportions of total livestock feed requirements and timber requirements will not be met from within the Region.

Applied water requirements in 1965 were about 35 million acre-feet. By 2020 they will increase to somewhere between 46 and 56 million acre-feet based on the different economic and population projections (Base Plan, OBERS, and Series D-1970). In-stream flows needed for fishery enhancement, water quality control, stream recreation, and possible changes in Delta outflows have not been evaluated and are not included in the projected water requirements.

Water projects under construction, together with available water supply reserves, will provide an additional 5 million acre-feet per year over and above present use leaving a supplemental water development requirement of between 5 and 13 million acre-feet per year by 2020. Adequate water resources from a number of alternative sources are available within the Region to meet these additional requirements.

CONCLUSIONS

A detailed project development plan is presented in Part V of Section B, which shows how future water requirements can be met by conventional methods of surface water development. This type of plan would require, for Base Plan projections, construction of dams on several North Coastal rivers, and as a result there would be opposition to such an alternative.

Effects of the regionwide project development plan on the natural environment noted in Section B, Part VI, include reducing the wild and scenic potential of portions of 13 streams (comprising 1,200 stream miles) and an effect on about 1,950 miles of anadromous fishery streams. Ecological impacts on the San Francisco Bay, Sacramento-San Joaquin Delta, and Eel River Delta are uncertain.

Gaseous pollutants resulting from the burning of fossil fuels are currently the subject of a worldwide research effort. Although techniques for the removal of many of these pollutants are presently being utilized, and on a fairly successful basis, more research is needed in order, if possible, to reduce these gaseous emissions to the levels necessary to meet many of the present and proposed air quality standards. If projected power production from fossil fuels materializes without an improvement in present technology, there would be substantially increased pollution levels. In some areas, even with new technology, use of alternative energy sources, such as nuclear fuels, may be required.

The total estimated installation cost of the project development plan, for the period 1966-2020, ranges from $24 billion to satisfy Series D-1970 projections, and $26 billion for OBERS, to $30 billion for the Base Plan projections. In addition, operation, maintenance, and replacement costs (Base Plan) are estimated to increase from $225 million in 1980 to $663 million in 2020. OM&R costs for the other projections would be correspondingly less. These water development costs (installation and OM&R) would average $824 million per year during the first time frame (1966-1980) for Base Plan projections or $735 million per year for OBERS. During the initial five years of the first time period, the reported actual expenditures by federal and nonfederal agencies was $1,095 million per year. However, the estimated federal share of the first time period average annual cost ranges from $387 million for Base Plan to $315 million for OBERS, whereas the reported average annual federal expenditure for the first five years has been only about $163 million.

Alternatives to the project development plan for providing additional water supplies, which were considered in this study, include structural measures such as desalting, waste water reclamation, and geothermal development, and nonstructural or other measures such as weather modification, watershed management, improving project operation efficiency, reducing crop irrigation requirements, increasing crop yields, lowering per capita water use in urban areas, and reducing water requirements by importing more goods and services. While there appear to be substantial potentials for a number of these alternatives, more data and study are needed regarding physical feasibility, costs, and legal and institutional aspects.

Important conclusions resulting from a sensitivity analysis (Section B, Part VI) and from analyzing key assumptions are: (1) If projected increases in the markets for rice and cotton fail to materialize, applied water requirements in 2020 could be as much as 5 million acre-feet per year lower than projected. (2) In a developed economy,

like that of the California Region, increased water development for irrigation produces relatively small changes in total employment and income. (3) Increases in the market supply of agricultural products, associated with a higher level of production than projected by OBERS, will have major impacts on commodity prices and farm income unless the higher level of production in the Region is offset by lower levels of production in other regions that supply the market. (4) A redistribution of population within the Region would have a relatively small effect on total regional water requirements.

The Plan of Action (Section B, Part VII) resulting from this study is developed from an approach to planning that strives to reduce uncertainties, maintain flexibility, utilize alternative approaches, employ sequential decision-making, and recognize multiobjectives. Two principal goals to be attained by the action program are "best use of resources" and "satisfying future needs".

A major concern and an important element of the action plan is to determine the practicability and desirability of evaluating, in quantitative terms, the objective of environmental quality. A comprehensive environmental resource inventory is needed as a prerequisite to sound environmental planning. Human needs for environmental quality must be established and alternatives formulated to satisfy those needs. Early action is required to insure preservation of remaining important natural resources such as free-flowing streams, wilderness, and natural areas. New programs or projects that would cause significant negative impacts on the natural environment should be implemented only if these programs or projects add substantially to the overall well-being of the people, taking into account the natural environment losses.

Growth in the California Region during the initial five years of the first time frame has produced a smaller increase in water supply demands than that projected under Base Plan assumptions. As a result, water supply from existing, under construction, and authorized projects will be adequate to meet projected water needs until the mid-1980s or

possibly longer. Studies and investigative programs are recommended for initiation and expansion during the next decade to determine the potential and costs of providing new water supplies from waste water reclamation, geothermal wells, desalting, weather modification, improved project operations, reduced irrigation requirements, lower per capita M&I use, and higher crop yields. At the same time, studies of and planning for conventional surface water development must continue in order to provide a base line from which other alternatives can be compared and evaluated. In some cases conventional methods of surface water regulation may permit the best total use of resources and most comprehensively satisfy future needs including streamflow enhancement. Recommendations are made in the Plan of Action for economic studies that would increase our capability to make reliable projections and would develop an analytical system to evaluate price impacts. The essence of the recommended course of action is to emphasize development of the information needed to make rational decisions at critical points in time.

Development of the portion of the Plan of Action to satisfy needs for damage reduction -- flood, erosion, wildfire -- generally result in recommending continuing surveillance and evaluation of damage and possible alternative means to reduce damages. Special attention should be given to evaluating the effect of damage control measures upon the environment and integrating these measures with solutions to other problems.

Considerable attention should be given to preparation of more explicit plans for meeting the needs of recreationists. Specific land and water areas and kinds and number of recreation facilities that will be needed must be delineated before the needs can be properly satisfied. Federal, state, and local governments share in the responsibilities to implement programs aimed at providing recreational opportunities. Modifying the existing legal, institutional, and financial arrangements is of primary importance in meeting future recreation needs. By providing

the proper mechanisms and tools, the many government entities at each level and the private sector can accept their responsibilities in developing and maintaining recreational opportunities. Likewise, the needs of hunters, anglers, and "animal watchers" cannot be met until specific plans are prepared that show what lands, waters, and facilities need to be preserved, acquired, or developed. During the next decade, it should be possible to initiate preparation of detailed plans outlining specific actions to satisfy future recreation and fish and wildlife needs.

The Plan of Action, as related to navigation and shoreline needs, is generally independent of program requirements for other functions. The basic programs of these two elements as set forth in Section B, Part V, require the timely development and funding to permit implementation. Future studies should relate the effects of navigation and shoreline facilities upon the environment and consideration of possible legal and institutional changes.

Actions to solve the potential problems of electric power shortages and water quality degradation must come from both public and private interests. Individual concerns must be expressed and brought to the attention of those agencies that have the capability and authority to implement positive action. Government must assume its responsibility for establishing firm policy and setting realistic standards. Furthermore, it must vigorously enforce compliance with adopted standards. Also, and of equal importance, government must encourage and assist industry in its expanding role of meeting human needs -- social, as well as functional.

RECOMMENDATIONS

It is recommended that local, state, and federal officials, and private interests, with responsibilities for the preservation, development, and use of the California Region's water and related land resources:

1. Use the data and findings in this report as a basis for continuing and initiating programs to meet needs and eliminate problems.

2. Use the Plan of Action in Section B of the report to help establish priorities for new studies, research, data collection and analysis, and other actions required to provide a basis for informed, intelligent, and timely decisions to meet the people's water and related land resource-based needs, and, at the same time, enhance the environment.

It is finally recommended that the Water Resources Council:

1. Accept this report and its appendixes, as a guide in the coordination of programs and review of proposals concerning water and related land resources of the California Region.

2. Provide for or support the further development and updating of conclusions, plans, and alternatives presented in this report.

3. Transmit this report to the Congress for its use in the consideration of programs and proposals for the preservation, development, and use of the water and related land resources of the California Region.

SECTION B

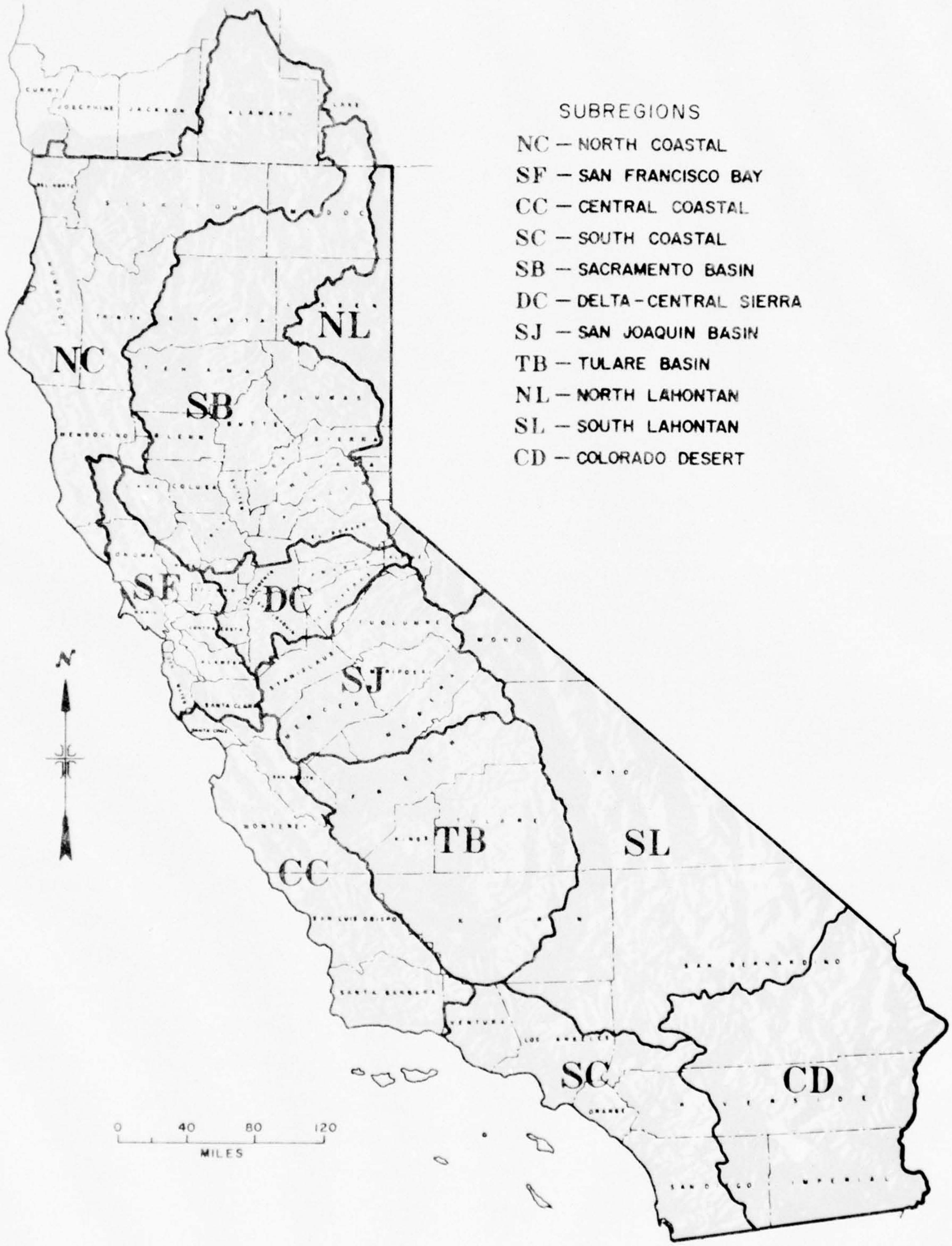
PART I - INTRODUCTION

Planning for the wise use and development of our water and related land resources is essential to economic growth and the physical and social well-being of the people of the region and the nation. Providing adequate water supplies of suitable quality to meet both instream and out-of-stream beneficial needs and uses, protecting human values, and the quality and productivity of our resources from degradation and damage, and enhancing resource use opportunities are all accomplishments which can best result from long-range comprehensive planning.

When resources are abundant in relation to requirements for those resources, it takes very little farsightedness to supply people and machines with food, fiber, fuel, and other necessities. However, when we recognize that resources are limited and that requirements continue to increase and compete for use of those limited resources, the need for a *framework plan* to guide future actions becomes self-evident.

BACKGROUND

Appendixes I, II, and III -- "History of Study," "The Region," and "Legal and Institutional Environments" -- furnish background material. Appendixes IV through VII -- "Economic Base and Projections," "Water Resources," "Land Resources and Use," and "Mineral Resources" -- include basic resource information utilized in the other appendixes. Appendixes VIII through XVII -- "Watershed Management," "Flood Control," "Irrigation and Drainage," "Municipal and Industrial Water," "Recreation," "Fish and Wildlife," "Electric Power," "Water Quality, Pollution, and Health Factors," "Shoreline Protection and Development," and "Navigation" -- are functional appendixes, each dealing with a particular recognized phase of water and related land resources development, use, or management. The findings of all appendixes were utilized in the preparation of this appendix.



MAP I

SUBREGIONS OF CALIFORNIA REGION

Most of the detailed studies and the presentation of results are broken down by 11 subregions (Map 1) and three time frames (1966-1980, 1981-2000, and 2001-2020). These details may be found in the appropriate appendix reports but are not necessarily carried forward into this appendix.

There is available in the files of California Region framework participants a "technical supplement" to the General Program and Alternatives appendix. This document first appeared as Volume A of Appendix XVIII in July 1970 and was prepared on a regional basis. It was supplemented by a two-part Volume B which was prepared on a subregional basis. These preliminary draft reports are not a part of the final report but serve only to record the process through which the plan formulation evolved.

PURPOSE AND SCOPE

The California Region Framework Study has been an effort to assemble and compile available data concerning water and land resources and to evaluate the opportunities for their use and development. Secondly, the study has endeavored to look ahead and estimate the potential range of human needs for goods and services. Finally, alternative means and opportunities for developing resources to satisfy these needs have been identified.

This appendix emphasizes resource conservation and development to satisfy various projections of future needs and alternative planning objectives. It describes various means to satisfy future needs and presents a plan for future action. Special attention is given to problems, conflicts, and the consequences of changing several variables or assumptions related to the planning process.

This appendix brings together the inventory of resources and summarizes the functional requirements that are contained in other appendixes. It presents general plans and alternatives to satisfy projected needs for goods and services. Finally, it presents a

plan of action to serve as a guide for the management, use, and development of the Region's water and related land resources.

Three economic projections, OBERS, Base Plan and Series D - 1970, were developed upon which water and related land requirements and a framework plan were based. The OBERS projections were developed by the Office of Business Economics (Department of Commerce) and the Economic Research Service (Department of Agriculture). The OBERS projections are nationally consistent as their projections include each Water Resource Region in the United States. Principal components of the OBERS projections are population, employment and income by major industry and economic subregion, and crop production for important national crops by regions.

Base Plan projections are a regional modification of the OBERS projections. Regional population estimates are the same for Base Plan and OBERS but the distribution of population within the Region is different. The major difference is in crop production. The OBERS level of crop production was modified for several major crops with the result that total agricultural production for Base Plan is considerably higher than for OBERS.

Series D-1970 projections are a modification of the Base Plan projections to reflect a lower population growth rate. OBERS and Base Plan projections are based on a series "C" growth rate which gives 54.9 million population by year 2020. Series D projections reflect a lower growth rate and result in a regional population of 44.8 million by year 2020. Series D-1970 agricultural production projections were obtained by reducing Base Plan projections, but somewhat less than in proportion to population.

Throughout these studies, major emphasis was placed upon developing data and plans for Base Plan projections - with lesser emphasis of OBERS and Series D-1970 projections. Series D-1970 projections were incorporated only towards the end of the study as recent trends of birth rates and migration to California became more evident.

OBJECTIVE

The basic objective in the formulation of the framework plan is to provide a broad guide to the best use, or combination of uses, of water and related land resources of the Region to meet foreseeable needs. To achieve this basic objective, consideration is given to several specific planning objectives. Recently, a special task force of the Water Resources Council outlined an approach to planning that centers on specific consideration of four separate planning objectives -- to enhance (1) national economic development, (2) quality of the environment, (3) social well-being, and (4) regional development. As the task force report was not available until the end of this study, their specific approach is not followed in this appendix. However, the multiobjectives were considered in developing and evaluating alternatives and in developing the plan of action in PART VII.

CRITERIA

The following criteria are used in formulating the plans and alternatives.

(1) Framework investigations are based upon the expectation of an expanding regional economy in which increasing amounts of goods and services are likely to be required to meet the needs of a growing population and higher levels of income.

(2) Elements of framework plans are not subject to analysis of economic justification. Therefore, water development features and alternative plans are neither selected nor sized on the basis of economic benefits. They are chosen during progressive planning steps using general relations, reasoned approximations, available data, and the judgement of experienced planners.

(3) Water and related land resource requirements for electric power, fish and wildlife, flood control, irrigation and drainage, municipal and industrial use, navigation, recreation, shoreline

protection, water quality control, and land management are considered in the study.

(4) Generally, information used in plan formulation is supported by the other appendixes. However, additional or updated information is utilized when necessary to make the analysis, evaluation or plan more comprehensive.

(5) The multiple-use concept and competing uses of resources are considered in the studies.

(6) Framework plan costs do not include elements unless they are a part of water resources development. Where such facilities and programs are not a part of water resources development they may be included as associated costs.

(7) While the primary focus of the framework study is to evaluate the role of the Region's water and land resources to meet future needs, alternatives that consider increased importation of goods and services into the Region are evaluated.

(8) Available water allocated under compacts, agreements, or laws, but not presently in beneficial use of the allottee is considered available for future beneficial use of the allottee (state or other organization unit). Appropriate state laws are used as guidelines for determining priorities of use among competing areas and uses.

(9) All existing and authorized projects that have inter-regional diversion are recognized; and all water subject to distribution between regions in accordance with existing Federally approved compacts or other legal agreements is distributed in accordance therewith.

(10) The flexible interchange of water resources among sub-regions is assumed to continue in the future. Recognition is given, however, to existing inter-regional systems and the legal and institutional constraints under which they operate. Sub-regional requirements for land resources, including recreation and

fish and wildlife needs, are not considered to be transferable among subregions and deficiencies may exist in one subregion while surpluses appear in others.

(11) July 1, 1965, is the date of reference for framework studies and serves as the effective point in time for which all basic data and conditions relevant to the study are compiled. All water projects constructed and in operation in the Region prior to, or during, the calendar year 1965 were included in evaluations of the base year situation. Any project placed in operation after 1965 is included in later periods as appropriate.

(12) Cost estimates for broad components of the framework plan are of reconnaissance quality and detail. A general indication of Federal and non-Federal funding is estimated. Costs include total installation costs and related nonstructural program costs. Operation, maintenance, and replacement costs are related to the end of the time frame period and only to those installation costs incurred during that particular time frame.

PROCEDURES

The procedures for formulation of the framework plan can be summarized in nine steps:

(1) Identification and measurement of the goods and services required to satisfy human needs for each set of economic projections.

(2) Identification of various means to satisfy needs for goods and services.

(3) Identification and measurement of requirements for water and related land resources to meet the needs for goods and services enumerated in Step 1 by the various means described in Step 2.

(4) Inventory of water and related land resources and evaluation of their capability for meeting current and projected needs and requirements.

(5) Identification of various techniques, programs, and projects for developing necessary water and related land resources.

(6) Formulation of specific programs and projects (plan elements) that would satisfy needs and requirements and estimating their cost. *A project development plan is presented not as a recommended plan but as an example using conventional means for water development.*

(7) Selection and discussion of other plan elements to demonstrate alternative methods for meeting resource demands and to examine the extent to which they achieve alternative planning objectives.

(8) Evaluation of alternatives to identify problems and conflicts and determine their potential acceptability, effectiveness, efficiency, and completeness.

(9) Preparation of a plan of action that sets forth a guide of where we go from here, what decisions have to be made, at what time, and what do we need to know in order to make appropriate decisions.

PART II - NEEDS FOR GOODS AND SERVICES

The needs for goods and services of a region result from the desires of the people. Goods and services are needed to satisfy the basic human wants for food, clothing, and shelter, and for secondary wants such as recreation, esthetics, and security.

Certain needs require the furnishing of goods and services to meet a consumptive need of the people. These include food and fiber, consumer goods, and electric power. Other needs involve the furnishing of a service to eliminate or reduce problems that cause economic or other losses. These latter needs include relief from flood damages, damages caused by shoreline and watershed erosion, wildfire damage, and degradation of water quality.

ECONOMIC PROJECTIONS

The principal economic variables related to the needs for goods and services are population, employment, income, and gross regional product. These variables are summarized in Table 1 which shows the 1965 estimate and projected values for target years 1980, 2000, and 2020 for the California Region. Values are shown for the Base Plan, OBERS, and Series D-1970 projections. Further details are contained in Appendix IV, Economic Base and Projections.

PRESENT (1965) & FUTURE NEEDS

Needs for goods and services for the base year, 1965, were estimated based upon existing data and reasoned judgement of planners, economists, recreationalists, and other specialists in the various fields of resource development and use.

Based on the economic variables shown in Table 1, needs for goods and services were projected to target years 1980, 2000, and 2020 for Base Plan, OBERS, and Series D-1970 projections. Present and projected needs are discussed in detail in various appendixes and are summarized in Table 2 and on the following pages.

Table 1
ECONOMIC VARIABLES
CALIFORNIA REGION

Projection	1965	1980	2000	2020
	Population (1,000 people)			
Base Plan	18,106	25,465	38,181	54,941
OBERS	18,106	25,465	38,181	54,941
SD-70	18,106	24,200	33,900	44,800
	Employment (1,000 employees)			
	Agriculture, Forestry & Fisheries			
Base Plan	277	300	317	320
OBERS	277	267	254	241
SD-70	277	-	-	-
	Manufacturing & Mining			
Base Plan	1,746	2,527	3,596	4,926
OBERS	1,746	2,508	3,563	4,897
SD-70	1,746	-	-	-
	Armed Forces			
Base Plan	308	291	291	291
OBERS	308	291	291	291
SD-70	308	291	291	291
	Other[a/]			
Base Plan	4,803	7,713	11,565	17,004
OBERS	4,803	7,357	11,545	16,980
SD-70	4,803	-	-	-
	Total employment			
Base Plan	7,133	10,813	15,769	22,542
OBERS	7,133	10,423	15,654	22,410
SD-70	7,133	-	-	-
	Income[b/]			
	Total ($ million/yr)			
Base Plan	56,038	121,162	300,904	725,551
OBERS	56,038	121,162	300,904	725,551
SD-70	56,038	115,144	267,166	591,629
	Per capita ($/capita/yr)			
Base Plan	3,095	4,758	7,881	13,206
OBERS	3,095	4,758	7,881	13,206
SD-70	3,095	4,758	7,881	13,206
	Gross Regional Product[bc/] ($ million/yr)			
Base Plan	69,000	160,300	393,000	951,500
OBERS	69,000	157,800	391,900	945,000
SD-70	69,000	150,000	348,700	770,000

a/ Includes Services Industries sectors.

b/ Constant 1958 dollars.

c/ Value added.

Table 2

NEEDS FOR GOODS AND SERVICES
CALIFORNIA REGION

Goods and Services	Units	Present (1965) Need	Estimated Future Need: Base Plan 1980	Base Plan 2000	Base Plan 2020	OBERS 1980	OBERS 2000	OBERS 2020	SD-70 1980	SD-70 2000	SD-70 2020
Food & Fiber											
Feed crops	million tons/yr	12.0	21.4	26.8	32.5	21.1	26.4	32.0	20.3	23.8	26.5
Food crops	million tons/yr	24.8	35.6	52.1	71.2	31.0	43.1	57.7	33.8	46.3	58.0
Oil & fiber crops	million tons/yr	0.8	1.3	1.9	2.4	1.3	1.8	2.2	1.2	1.7	2.0
Livestock & products	million tons/yr	6.1	7.9	10.1	13.0	7.9	10.1	13.0	7.5	9.0	10.6
Economic Activities											
Agricultural processing	$ billion/yr	8.5	11.0	14.7	19.8	10.1	13.0	17.3	10.3	12.4	15.0
Manufacturing & mining	$ billion/yr	28.4	56.1	129.7	283.6	56.1	129.7	283.6	50.3	101.2	182.8
Services, utilities & construction	$ billion/yr	59.5	121.4	291.9	678.9	121.4	291.9	678.9	111.8	241.8	497.8
Damage Reduction											
Flood	$ million/yr	107.4	171	324	659	166	306	563	164	283	505
Shoreline	$ million/yr	9.9	15.7	29.7	48.9	15.7	29.7	48.9	15.7	29.7	48.9
Erosion & sediment	million acres	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Wildfire	$ million/yr	15.5	18.0	27.0	38.8	18.0	27.0	38.8	17.1	24.0	31.7
Water quality	population equivalent (million)	31	43	60	82	43	60	82	41	54	66
Recreational Opportunities											
General a/	million recreation-days/yr	905	1,352	2,067	3,024	1,352	2,067	3,024	1,287	1.838	2,464
Fishing	million angler-days/yr	23.8	38.7	59.7	85.0	38.7	59.7	85.0	36.8	53.1	69.7
Hunting	million hunter-days/yr	9.8	15.0	21.2	27.1	15.0	21.2	27.1	14.2	18.8	22.2
Electric Power											
Energy requirements	1,000 gwh/yr	96	296	1,034	2,537	296	1,034	2,537	281	920	2,055
Peak demand	1,000 mw	17.3	51	175	423	51	175	423	48	155	342
Navigation											
Waterborne commerce	million short tons/yr	99.0	153.7	227.5	323.2	153.7	227.5	323.2	151.7	224.7	315.5

a/ Includes shoreline recreation and boating in navigable waters.

Food and Fiber

Future needs for food and fiber are based upon projected national population, per capita consumption, export, manufacturing use, and changes in consumption patterns resulting from higher per capita income. The national production needs are then allocated among the several regions. For Base Plan and OBERS projections, the future needs for feed, oil and fiber, and livestock and product components are virtually identical but the Series D-1970 projection of needs are smaller, about in proportion to projected population.

Projected needs for food crops to be satisfied by the California Region are considerably higher for Base Plan than for OBERS and proportionally lower for Series D-1970. This results from the Base Plan projection (and Series D-1970 projection) assuming a greater regional production of food crops than assigned on a national basis.

Other Economic Activities

Economic activities, comprising agricultural processing, manufacturing and mining, and services are projected to target dates 1980, 2000, and 2020, and are derived from OBE projections of earnings from these same sectors. On a regional basis Base Plan and OBERS projections are identical (except for agricultural processing) and Series D-1970 projections are about 30 percent less in 2020.

Recreational Opportunities

Projections of needs for general recreational opportunities are based upon population, participation rate by activity, and translation of activity days to recreation days. Future needs for hunting and fishing opportunities are based on population and per capita demand, adjusted for limiting quality factors.

Electrical Power

Basically, electrical power needs for the California Region are projected to target years by an extrapolation of historical data modified by judgement as deemed appropriate. Base Plan and OBERS needs are identical. Series D-1970 needs are derived from Base Plan needs, proportional to population.

Navigation

Future needs for waterborne commerce are determined from a summation of extrapolated projections of cargo categories by sub-region. Projected needs for Base Plan and OBERS are identical and Series D-1970 are about 2 percent less.

Flood Damage Reduction

Average annual flood damages in 1965 were about $107.4 million. Of this amount, about $50.8 million occurred in downstream areas (drainage basins greater than 250,000 acres) and about $56.6 million occurred in upstream areas (drainage basins less than 250,000 acres) with upstream category including some major urban damage centers. Flood damages are projected to increase substantially in the future due to an increase in population, economic activity, standard of living, and use of flood plain areas. Future flood damages are estimated by stream or river basin for the various assigned categories (forest, agriculture, residential, industrial, etc.) based upon the appropriate growth factor or factors. It is projected that if no additional flood protection is provided beyond 1965, average annual flood damages for the Region will reach $659 million by the year 2020 for Base Plan projections, $563 million for OBERS projections, and $505 million for Series D-1970 projections. Areas subject to flooding are shown on Map 2, at the end of the report.

Shoreline Damage Reduction

In projecting average annual damages due to shoreline erosion, it is assumed that future damages will bear a direct relationship to the changing values of damageable property within the shoreline zone. Damages are projected based on parameters derived for agricultural, residential and commercial, and public facility sectors. Because the shoreline is a very limited resource, its future development is relatively independent of growth rates of population and economic activities. Future shoreline erosion damage is therefore assumed the same for Base Plan, OBERS, and Series D-1970 projections and is estimated at $15.7 million, $29.7 million, and $48.9 million annually by 1980, 2000, and 2020, respectively. Areas of critically eroding shoreline are shown on Map 2.

Erosion and Sediment Damage Reduction

It is estimated that more than 44 million acres in the Region have a potential for moderate or severe erosion with 21.2 million acres actively eroding in 1965. Although projected increases in economic activities may modify future erosion problems, for purposes of this report it was assumed that the 1965 erosion acreages would remain constant to year 2020 for all projections. About 7.2 million acres of actively eroding land require programs specifically aimed at solving erosion problems. The remaining 14.0 million acres do not require specific treatment programs since they will be treated through the beneficial secondary effects of properly managed croplands, forage and timber production programs. Areas of critical erosion are shown on Map 3.

Wildfire Damage Reduction

Past experience indicates that the number of forest fires is directly proportional to population whereas the number of acres burned and dollar damage increase with population, but not in a

direct relationship. Thus, while population is projected to triple by 2020 for Base Plan and OBERS projections, wildfire damages are projected to increase to two and one-half times the present amount if the level of fire protection remains at the 1965 level. Additional fire prevention and suppression programs are needed on 64 million acres to prevent this projected increase in wildfire damages.

Water Quality

Water quality needs are generally proportional to population, per capita requirement for water, and economic activities. These needs include development of water quality standards consistent with beneficial uses to be protected for use as planning or development guidelines. They are essential to insure that the aquatic environment is protected from ecological distruption and impaired usefulness resulting from unwise or improper disposal of waste water from municipal, industrial, agricultural and other activities. Special water quality problems are listed in Table 3 and their locations shown on Map 3.

Table 3

MAJOR WATER QUALITY PROBLEMS
CALIFORNIA REGION

Subregion/Area	Problem	Cause
North Coastal		
(1) Crescent City & Humboldt Bay	Bacteriological contamination	Improper waste treatment and vessel wastes dumped in coastal waters.
(2) Klamath Lake	Eutrophic conditions and nuisance	Natural conditions and irrigation return flows.
(3) Klamath River	Fish kills	Algae concentrations from Klamath Lake.
(4) Most drainage basins	Siltation and turbidity	Erosion.
San Francisco Bay		
(5) San Francisco Bay	Depressed oxygen levels Elevated coliform bacteria Fish kills Nuisance, algal growths Bacterial pollution	Discharge of M&I waste water. Discharge of M&I waste water. Accidental oil spills and deliberate toxic waste discharge. Discharge of several kinds of wastes. Sewer overflows.
(6) Russian River	Turbidity Algal blooms	Improper land use and imported water from Eel River. Improper waste treatment.
Central Coastal		
(7) Monterey and Carmel Bays	Pollution	Massive oil spills and inadequately treated waste discharges.
(8) Lower Salinas Valley	Sea-water intrusion into ground water	Overpumping of groundwater.
South Coastal		
(9) Ground-water basins	Sea-water intrusion	Overdraft.
(10) Coastal areas	Adverse effects on kelp beds	Ocean disposal of municipal waste waters.
(11) Near shore areas	High coliform bacteria concentrations	Floating material of waste water origin.
(12) Coastal lagoons-estuaries	Excessive algal growth, oxygen depression and odors	Runoff carries enriching nutrients from urban and irrigated lands and wastes from military, commercial and pleasure craft.
Sacramento Basin		
(13) Keswick Reservoir	Fish kills	Occasional mine drainage discharge.
(14) Clear Lake	Algal concentrations, odors	Natural and man made causes.
Delta Central		
(15) San Joaquin River Delta	Eutrophication - depressed oxygen levels	Unnatural flow patterns from pumping and waste discharge during low flows.
(16) Delta system	Turbidity	Continual dredging for ship channels.
(17) Western Delta	Fish kills	Toxic waste discharges.
San Joaquin		
(18) Stanislaus River	Algae, aquatic plants, fish kills	Large salt loads, nutrients from municipal, industrial and agricultural sources. Diversion of natural flow from San Joaquin River and its tributaries.
(19) Tuolumne River	"	"
(20) San Joaquin River	"	"
(21) Lower San Joaquin River	High salt content	Saline water from abandoned gas wells.
(22) Ground-water basins	High salt content	Increasing drainage problems.
Tulare Basin		
(23) Ground-water basins	Ground water exceeds recommended maximum total dissolved solids and nitrate concentrations exceed maximum levels recommended.	Worsening adverse salt balance conditions near the inland sink formed by Tulare Lake.
North Lahontan		
(24) Lake Tahoe	Degradation of quality and increase in turbidity	Solid wastes and surface runoff from land development and installation of shoreline structures.
(25) East Fork Carson River	Waters of tributary have become toxic	Acid wastes from abandoned mine.
South Lahontan		
(26) Mono Lake	Water quality is being degraded	Diminishing inflow.
(27) Various recreation areas	Minor water quality problems	Failing septic tanks.
Colorado Desert		
(28) Agricultural areas	Adversely affected	Application of high mineral content water from Colorado River.
(29) Salton Sea	Eutrophic and increasing salinity	Agricultural waste discharges.
(30) Salton Sea	Fish kills	Decreasing oxygen from decomposition of algal blooms and waste discharges from Mexicali into New River.

PART III - RESOURCE SUPPLY

California Region resources, to be used in satisfying the foregoing needs, are products of land, water, and air. And the Region's resources are varied. It has the lowest valleys, some of the highest mountains, the driest deserts, and wet rain forests. The Region has its proportional share of the air, but it also has its problems with air pollution.

WATER

The three major sources of water supply in the California Region are (a) surface runoff resulting from precipitation within the region, (b) ground water, both that accumulated through the ages and normal recharge, and (c) diversions from the Colorado River. Water supply development in the past has generally been limited to these sources because they were the most economical to use and were sufficient to meet all needs and requirements. In addition, lesser amounts of water are obtained by reclamation of waste water, weather modification activities, and desalination of sea water. While surface water supplies in the California Region are still reasonably abundant -- at least in the North Coastal and Sacramento Basin Subregions -- there is increasing competition for this resource.

The mean precipitation over the California Region is 23 inches annually which is equivalent to 200 million acre-feet of water. Under natural or pre-development conditions, it is calculated that about 130 million acre-feet was consumed by native vegetation or evaporated and the remaining 70 million acre-feet was runoff. It is important to note that over 50 million acre-feet of this runoff occurred in two subregions, North Coastal and Sacramento Basin.

Early settlers in the Region diverted a portion of the surface runoff and used it for domestic and agricultural purposes.

Depending upon location within the Region, normal streamflows were adequate, both in quantity and in time, to meet the needs of the people. As more and more water was withdrawn from streams, summer flows were soon insufficient to support additional requirements. Therefore, the next logical step in surface water development was to provide regulatory storage whereby the larger winter flows could be captured and retained for subsequent release and beneficial use during summer months.

Present Supplies

In 1965, the Region's water resources were regulated to a level that would support a total applied water requirement of 36.9 million acre-feet per year for agricultural, domestic, and industrial purposes and an estimated conveyance loss of 4.4 million acre-feet. In addition, minimum regulated flows are maintained in some streams for hydroelectric power, water quality control and fisheries, and for navigation in Sacramento River. Included in the total application supply is an estimated 4.5 million acre-feet per year that results from local reuse of return flows. This amount is deducted from the total application supply in calculating "developed water supply" for out-of-stream use. There is an additional quantity of regulated surface water, estimated at about 3.4 million acre-feet per year, that presently (1965) does not have a conveyance system to deliver it to planned service areas and is therefore not included as part of the present developed water supply. As a result, the total developed water supply in 1965 is calculated to be 36.8 million acre-feet and is presented in Table 4 by subregions.

Surface water regulation and development takes place in each subregion except the Colorado Desert. (Colorado River water is treated as an import.) In total, 20.1 million acre-feet per year of surface water was regulated in 1965 but a portion of this amount, 3,413,000 acre-feet, was without conveyance facilities to deliver

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Table 4

PRESENT DEVELOPED WATER SUPPLY (1965)
(1,000 acre-feet/yr)

Subregion	Regulated Surface Water		Ground Water Pumpage		Import	Export	Developed Water Supply (1965)
	With conveyance	Without conveyance	Safe yield	Overdraft			
North Coastal	3,345		150			950	2,545
San Francisco Bay	75	(98)	300	70	1,186		1,631
Central Coastal	113		900	70			1,083
South Coastal	180		1,600		1,505		3,285
Sacramento Basin	7,789	(3,315)	1,600	100	807	1,987	8,309
Delta-Central Sierra	2,359		600	150	1,976	2,509	2,576
San Joaquin Basin	3,825		1,750	50	1,675	1,531	5,769
Tulare Basin	2,800		4,200	2,300	1,331		10,631
North Lahontan	379		60		11	9	441
South Lahontan	328		300	300		325	603
Colorado Desert	0		100	200	5,346	1,180	4,466
	(21,193)a/	(3,413)b/			(13,837)	(8,491)	(41,339)a/
California Region	16,693		11,560	3,240	5,346	0	36,839

a/ An estimated 4,500,000 AF/yr. of this amount is local reuse of return flows and is not included as "developed water supply."

b/ Not included in total present developed water supply.

it to the intended areas of use. The remaining 16.7 million acre-feet is computed to be the 1965 developed water supply from surface sources.

Ground-water supplies also play an important role in the California Region and 14,800,000 acre-feet are presently pumped from ground-water storage annually. Of this amount, 3,240,000 acre-feet are in excess of that which can be extracted on a safe yield basis. A net overdraft of 2,560,000 acre-feet per year results since a portion of the excess pumpage returns by percolation to ground-water storage.

In addition to the regionally derived water supply, 5,346,000 acre-feet were diverted from the Colorado River in 1965. It is estimated that 446,000 acre-feet of Colorado River water returned to the river and the remaining 4,900,000 acre-feet was the depletion resulting from use in the California Region. In future years this depletion will be reduced to 4.4 million acre-feet, California's allotted share of the Colorado River.

Depletions

Current average annual depletion of the Region's natural runoff is about 25.2 million acre-feet. Accretions resulting from Colorado River imports and ground-water overdraft reduce this depletion to a net of about 17.7 million acre-feet annually. This results in a present (1965) impaired outflow of almost 52.5 million acre-feet per year (Figure 1).[1/]

The gross annual regional depletion of 25.2 million acre-feet includes all consumptive uses and losses of water associated with the application or delivery of water supply for agricultural, domestic and industrial purposes. It also includes irrecoverable

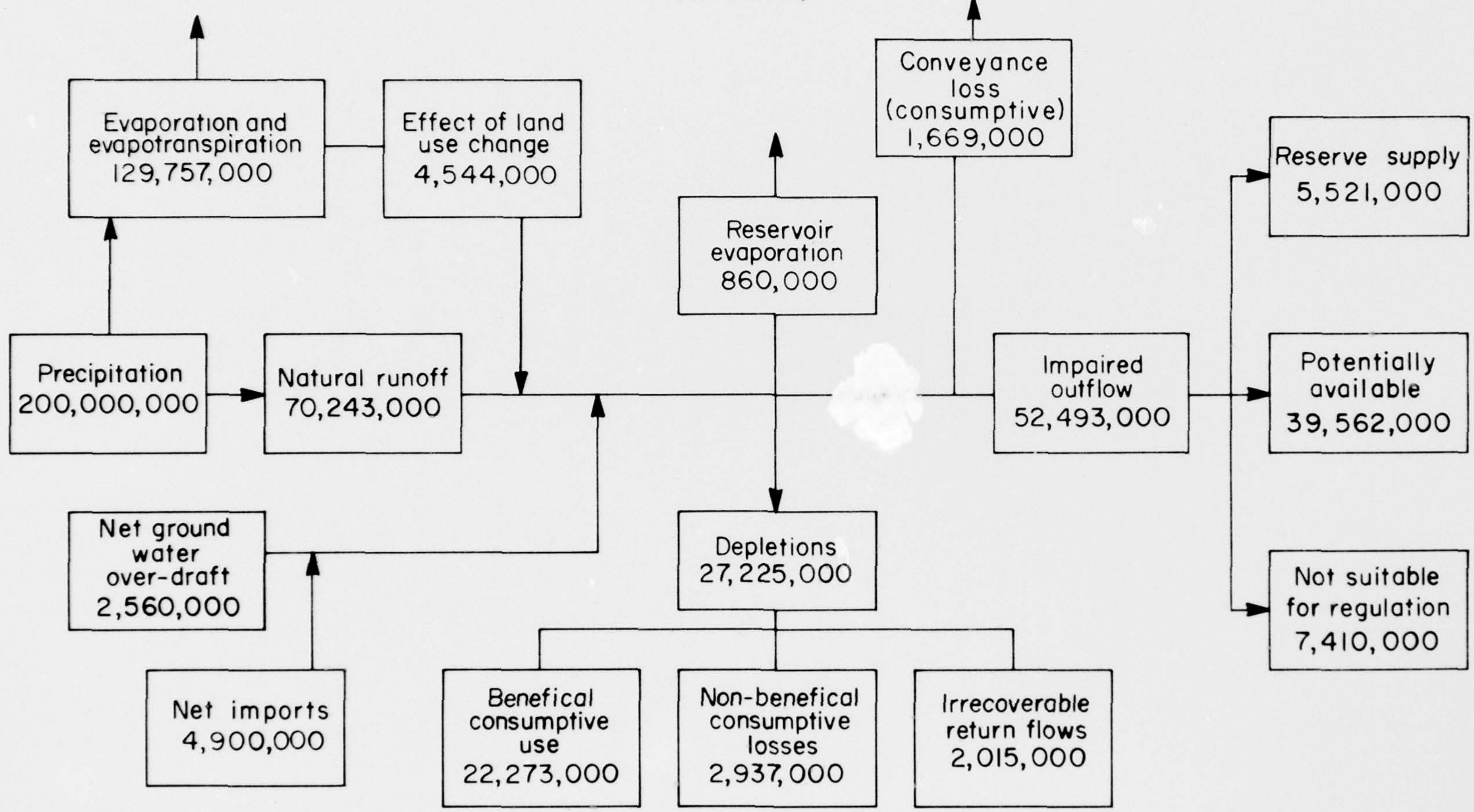
1/ Appendix V, "Water Resources," shows an average annual adjusted streamflow of 55,914,000 acre-feet per year. The difference reflects 3,421,000 acre-feet of developed runoff within closed basins, primarily Tulare Basin.

FIGURE I

MEAN ANNUAL WATER SUPPLY

Under 1965 Conditions

(acre-feet)



return flows such as municipal outflow discharged to the ocean and bays or agricultural return flows discharged to the Salton Sea. Other depletions of the natural water supply include net reservoir evaporation and consumptive losses associated with conveyance systems. Conveyance system losses that return to surface or groundwater supplies are not considered depletions and may in fact be counted as part of the regulated water supply.

A significant item affecting the gross depletion is the effect of land use change. When the natural vegetal cover is removed from the land and replaced by agriculture or municipal and industrial development there is usually a change in the consumptive use of precipitation. It is estimated that approximately 4.5 million acre-feet per year have been added to the natural surface runoff as a result of changing the land use of some fourteen million acres.

Unregulated Supplies

Not all of the present impaired outflow of 52.5 million acre-feet per year is considered to be available for future regulation or use. A portion has already been regulated and reserved for specific purposes, both instream and out-of-stream, and some is not physically suited to regulation. About 5.5 million acre-feet are already regulated and considered to be in reserve, even though distribution facilities are not available; another 7.4 million are physically unsuited for regulation. The remaining 39.6 million acre-feet are theoretically available for future development. A subregional distribution of this remaining amount is shown on Figure 2.

As indicated by the figure, more than three-fourths of unregulated water is in the North Coastal and Sacramento Basin subregions. Future demands on this remaining surface water supply will include both instream and out-of-stream purposes such as fisheries enhancement, water quality control, aesthetics, hydroelectric power, irrigation, and municipal and industrial use. Since 1965, some 4.9

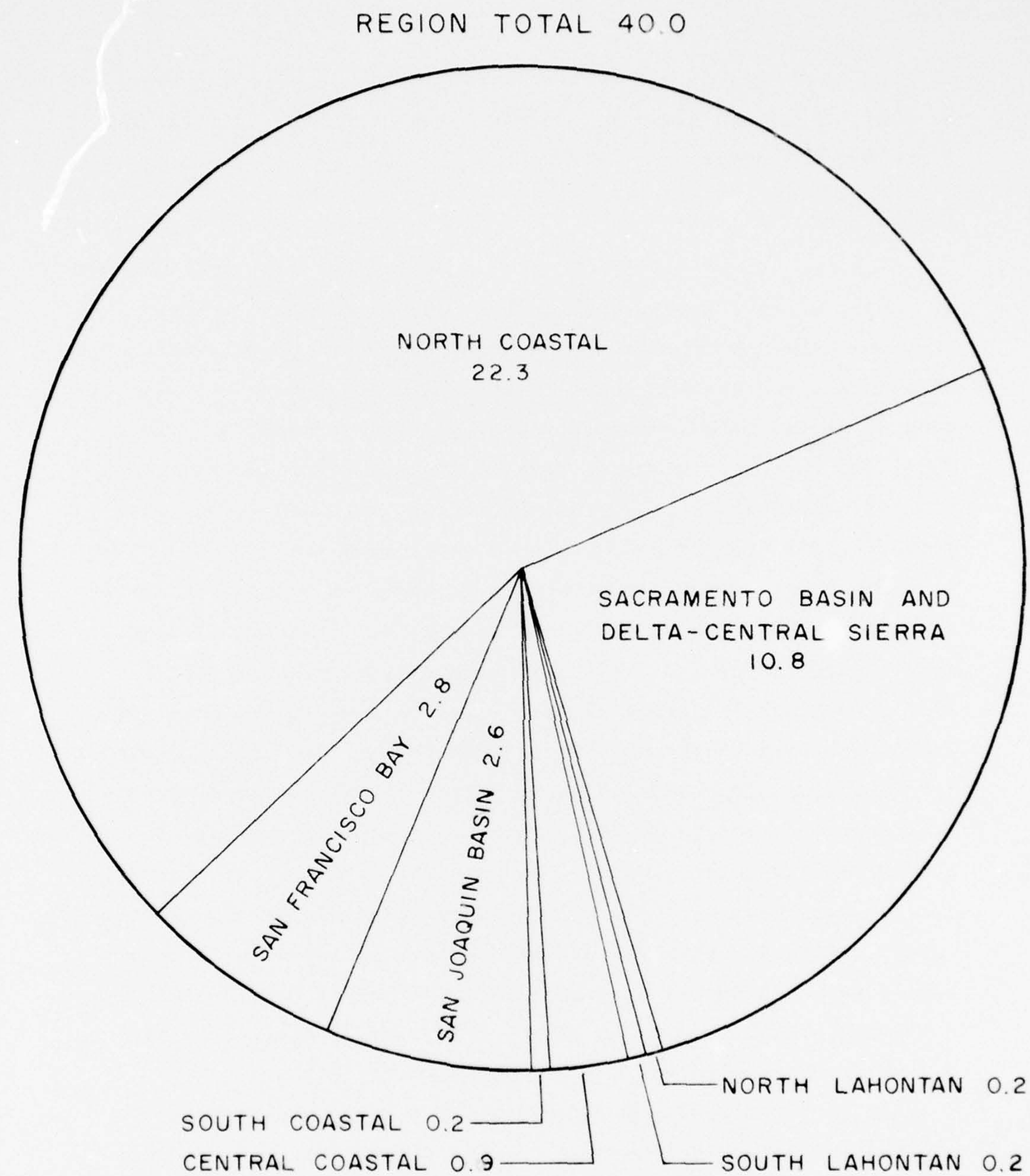


FIGURE 2
UNREGULATED WATER SUPPLY POTENTIALLY AVAILABLE IN CALIFORNIA REGION, 1965
(Million acre-feet per year)

million acre-feet of this potentially available water has been (or soon will be) regulated, much of it a result of the California State Water Project.

Future Supplies

Assured future developed water supplies for out-of-stream use are depicted on Figure 3 and include present developed water supplies plus new regulated water made available by water projects completed since 1965 or under construction and reduced by alleviation of ground-water overdraft and reduction of imports. Since 1965, surface water resource development has continued and completion of construction of current facilities will add 4.9 million acre-feet per year of new developed water supply.

The completion of conveyance facilities that were not available in 1965 will be accomplished during the first time period to make an additional 2.2 million acre-feet of regulated reserve supply available to areas of need. (It is anticipated that additional conveyance systems will be provided in the future to distribute the remaining 1.2 million acre-feet of reserve supply, but this supply is not included in Figure 3 because conveyance facilities are not available or funded.) The present reserve supply of 2.1 million acre-feet per year is considered part of the 1965 developed water supply, and when the present reserve is added to the new developed water supply and the additional supply made available by conveyance facilities under construction, the resulting total is 9.2 million acre-feet of assured supplemental water supply.

As previously stated, ground-water pumpage has currently created an overdraft situation in some areas. For planning purposes the ground-water pumpage overdraft of 3,240,000 acre-feet per year was assumed to be eliminated by year 2000 thus reducing the presently available water supply by a corresponding amount. There is perhaps another 100,000 acre-feet per year of safe ground-water

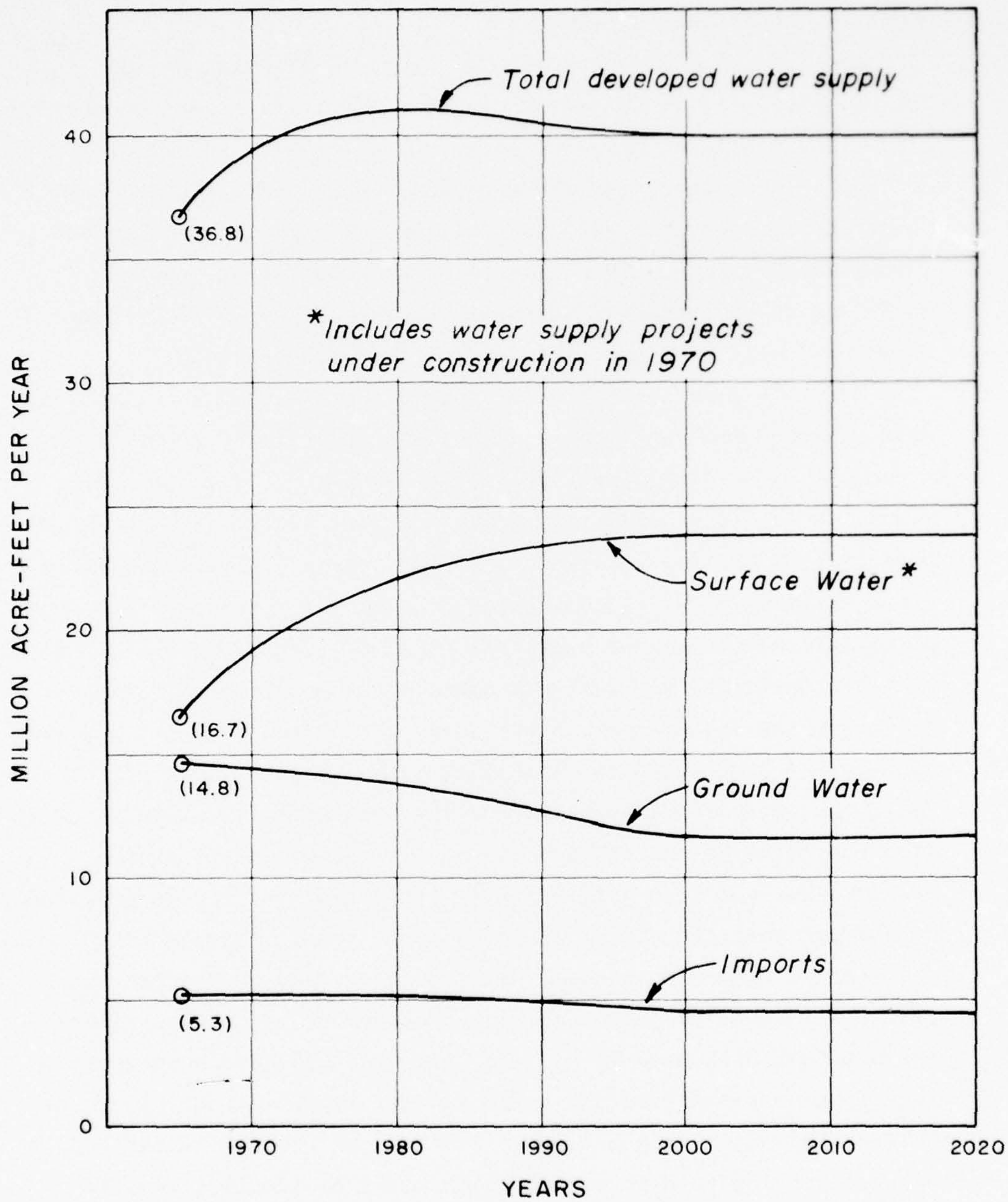


FIGURE 3
CALIFORNIA REGION
DEVELOPED WATER SUPPLY

yield available in the North Coastal Subregion and this has been added to the future water supply.

Another reduction in developed water supply will be the 500,000 acre-foot reduction of Colorado River diversions to comply with the 4.4 million acre-foot per year allowable depletion.

The future developed water supply, taking into account the construction program underway, allowing for stabilization of the ground-water system, and reduction of Colorado River imports, is projected to be just over 40 million acre-feet per year. Figure 3 shows the total developed water supply out to year 2020.

Over the past several years federal, state, and local agencies have investigated, at reconnaissance and feasibility level, a large number of water development projects. As part of the framework study, it was determined that additional surface water supplies of more than 12 million acre-feet per year are potentially available for satisfying out-of-stream water development requirements. Complete information is not available, however, regarding the quantity of water developed for instream use such as water quality control and fisheries enhancement. Therefore, use of the 12 million acre-feet may be limited by the necessity of maintaining some of the water resources involved for other instream uses. At this point in time the total effect of massive water projects on the fishery resource has not been determined or evaluated, but it can reasonably be assumed that the effect of major North Coast projects would be significant and in some cases detrimental. Also, the effect of such development on potential wild, scenic and recreation rivers has not been evaluated but it can be assumed to have some impact.

Table 5 summarizes the surface water supply potential of the California Region by subregions. It does not include water supply presently being used to satisfy 1965 water development requirements.

Table 5

SURFACE WATER POTENTIAL
To Satisfy Out-of-stream Water Development Requirements

(acre-feet per year)

Subregion	Reserve, Completed or Under Construction	Studies at Feasibility or Reconnaissance Level
North Coastal	74,000	7,464,000
San Francisco Bay	96,000	571,000
Central Coastal	6,000	332,000
South Coastal	0	55,000
Sacramento Basin	7,685,000	3,304,000
Delta-Central Sierra	291,000	151,000
San Joaquin Basin	882,000	108,000
Tulare Basin	0	316,000
North Lahontan	14,000	81,000
South Lahontan	157,000	0
Colorado Desert	0	0
California Region	9,205,000	12,382,000

LAND

The California Region covers 105,678,000 acres of which 1,496,000 acres are currently covered by water. The 104,182,000-acre land area contains some of the best and some of the least productive land in the nation. They are characterized by extreme variation in type of soil, slope, erodibility, climate, flood hazard, and related factors. The differences have a decided influence on wise land use and management practices. Ownership of the land also plays an important role in the determination of its management and use. About one-half of the Region is owned by the Federal Government and is administered by various federal agencies.

Food and Fiber Production Lands

Vegetal cover and present land use provide a fair description of the Region and establish a base from which plan formulation can depart. From these data, it can be determined what changes are necessary to reach planning goals that may be established and what

changes are required to produce specific quantities of timber, forage, and watershed protective cover. Figure 4 depicts the vegetal cover type of the Region.

The California Region supports a wide variety of vegetation as might be expected from an area with such a wide variety of topography and climate. Almost one-half of the Region retains substantially the original type of vegetal cover. Much of the other half consists of grassland areas where overgrazing has changed the species composition, and formerly timbered areas which have been changed to grass or brush as a result of wildfire, improper forest management, or deliberate conversions for grazing.

The most obvious changes have taken place on the remaining lands, those areas now used for cropland, for urban and industrial purposes, and for highways, utility rights-of-way, and reservoirs.

Nearly all of man's uses of the land disturb the soil and vegetation. This normally results in at least a temporary deterioration of the natural watershed conditions. Table 6 lists the acreage of each current land use and bears a relationship to vegetation cover. Some lands serve multiple purposes and therefore the summation of acres in use exceeds the total for the Region.

REGION TOTAL 105.6

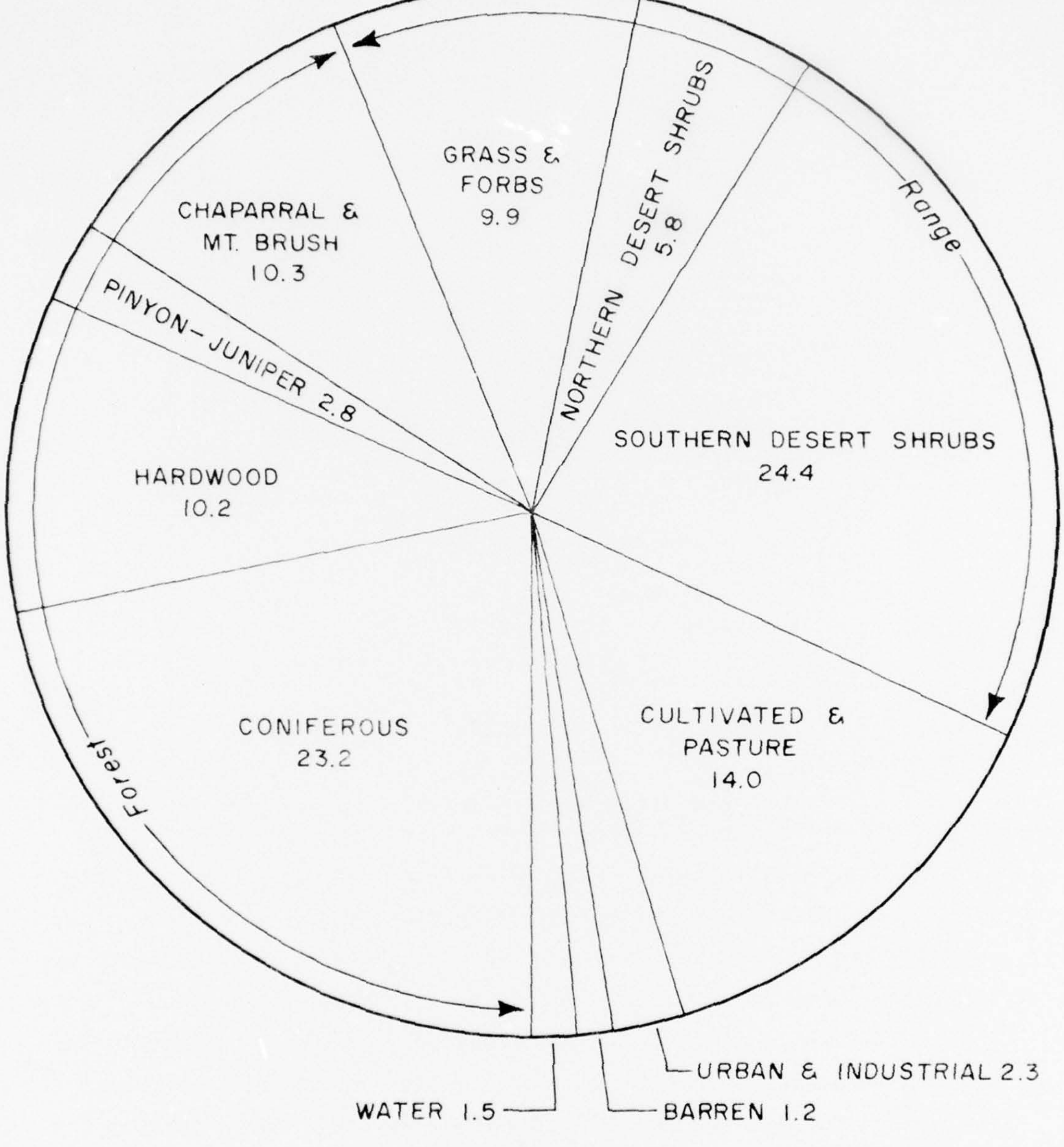


FIGURE 4
LAND AREAS BY COVER TYPE
(1965)
(Million acres)

Table 6

LAND USE IN 1965
(1,000 acres)

Land Use	Area
Food and Fiber Production	
Cropland	
Irrigated	9,134
Non-irrigated	1,607
Grazing	44,249
Timber	15,528
Other Resource Uses	
Recreation	
Developed	1,268
Undeveloped	65,152
Wilderness	4,014
Natural	713
Mineral	175
Fish and Wildlife	
Designated	1,001
Undesignated	100,962
Watershed	
Classified	690
Unclassified	103,492
Developed Nonresource Uses	
Urban-industrial	2,219
Military	3,773
Transportation and utilities	1,320

The suitability of land for various uses is based upon the natural limitations imposed by soils and physical geography. Land utilization which has been designed and planned in conformance with these limitations and if properly managed will not seriously detract from watershed values. In the planning process, requirements for land resources are determined by translating needs for food and fiber into requirements for land and water and then comparing the results with available quantities of suitable resources. A summary is given in Table 7 showing quantities of land suitable for irrigated agriculture, grazing, and timber production. Neither the productivity nor quality of the Region's land resources is depicted

by the acreage figures. Land suitable for other uses such as recreation and urban development is not presented because no specific land suitability limits were established for these uses.

Table 7

SUITABILITY OF LAND RESOURCES
(1,000 acres)

Subregion	Irrigable	Grazing	Timber
North Coastal	1,331	4,419	10,331
San Francisco Bay	830	2,106	456
Central Coastal	1,444	5,921	167
South Coastal	1,566	4,593	106
Sacramento Basin	4,055	7,395	6,399
Delta-Central Sierra	1,534	1,170	383
San Joaquin	2,646	2,248	1,187
Tulare Basin	5,061	4,920	1,111
North Lahontan	660	1,961	1,084
South Lahontan	2,674	6,984	7
Colorado Desert	2,079	4,003	139
California Region	23,880	45,720	21,370

Fish and Wildlife

Fish and wildlife resources of the California Region are also products of the land and water. A wide variety of wildlife has lived and prospered here. However, as the character of the Region has changed, so have its wildlife resources. With the change in habitat brought about by human encroachment, the California grizzly bear, timber wolf, jaguar, and sharp tailed grouse are now extinct in the Region. In 1968 the Bureau of Sport Fisheries and Wildlife listed ten rare and 26 endangered species including the California condor, Owens River pupfish, Piute cutthroat trout, California brown pelican, San Joaquin kit fox, and American peregrine falcon.

Also counted among the fish and wildlife resources are new species which have been successfully introduced to fill gaps and utilize available habitat and to help support hunting, fishing, and aesthetic enjoyment. Introduced species include the ring-neck

pheasant, chukar, turkey, nearly all warm-water game fish, and several cold-water game fish.

Anadromous fish generally inhabit the coastal streams from Monterey County north into Oregon. These species include chinook and coho salmon, steelhead trout, striped bass, American shad and sturgeon. All these anadromous fish, except coho salmon, are found in the Sacramento-San Joaquin Delta and in the lower reaches of most major Central Valley streams.

Resident fish inhabit over 29,500 miles of streams, 8,000 miles of canals, and about 548,000 acres of lakes, ponds, and reservoirs. Seven species of trout are found in the Region. The most numerous are rainbow, brown, brook, and golden trout. In many areas, demand for trout fishing exceeds supply, and over half of the present angler effort is provided by a catchable trout-stocking program. Warm-water game fish include large mouth and small mouth bass, bluegill, green and redear sunfish, black and white crappie, channel and white catfish, and brown bullheads. Inshore marine species are hooked, netted, picked, speared and dug in a narrow band of land and water extending seaward to 10 fathoms (60 feet) with a surface area of 540,000 acres.

Nearly all land and water of the California Region provide habitat for some wildlife or fish species. Big game animals are found on about 54 million acres, upland game on about 91 million acres, and waterfowl on about 626,000 acres of marsh and water, augmented seasonally by about 400,000 acres of suitable farm lands. In addition, the Region serves as many as 10 million wintering waterfowl that utilize the Pacific flyway. Private hunting clubs are popular in the Region and in 1965, there were about 1,000 waterfowl clubs controlling over 300,000 acres of land. There are also about 190 private pheasant clubs operating on about 165,000 acres of land and at least 500 deer hunting clubs on an undetermined number of acres.

Recreation

Recreation resources, like those of fish and wildlife, are also considered a product of land and water. About 71 million acres of land in the Region are shown in Table 8, Recreation Land Resources, as suitable for various recreational uses. In addition, most of the more than one million acres of water surface are suitable for recreational use.

Table 8

RECREATION LAND RESOURCES

Classification	Acres
Class I, High Density	55,000
Class II, General Outdoor	1,127,000
Class III, Natural Environment	65,151,000
Class IV, Unique Natural	714,000
Class V, Primitive	4,013,000
California Region	71,060,000

Although it appears that 70 percent of the land area of the Region would constitute an adequate resource base for recreation, the figure is somewhat deceptive. A more meaningful correlation emerges when the resource is classed by type and level of development, by its relative location to population centers, and by its capacity to serve recreation needs.

Recreation lands are classified into five broad classes of land, including the full range of physical resources from high density use to large, but sparsely used, primitive areas. Briefly, each class may be described as follows:

Class I - High Density Recreation Areas

Areas subject to intensive development and management for mass use.

Example: City parks

Class II - General Outdoor Recreation Areas

Areas subject to substantial development for a wide variety of specific recreation uses.

Example: Multipurpose reservoirs.

Class III - Natural Environment Areas

Various types of areas that are suitable for recreation in a natural environment and usually in combination with other uses.

Example: National forest lands

Class IV - Unique Natural Areas

Areas of outstanding scenic splendor, natural wonder or scientific importance.

Example: National parks

Class V - Primitive Areas

Undisturbed roadless areas characterized by natural wild conditions, including "wilderness areas."

Example: Wilderness areas

The more than one thousand miles of ocean shoreline is also a vital recreation resource of the Region. It generally falls into two categories, that of beaches for the more active uses such as swimming, surfboarding, and general recreation, and that of scenic beauty consisting of headlands, bluffs and canyons, and used primarily for more passive uses such as sightseeing and aesthetic enjoyment.

Special areas include natural, wilderness, research, national park, monuments and wild and scenic rivers. There are 68 existing and potential natural landmarks in the Region of which 9 have received registered status by the National Park Service. The Region contains 19 wilderness areas comprised of 1,632,000 acres. There are an additional 356,600 acres of primitive area under study for inclusion within the Wilderness System and 1,528,000 more acres of land proposed as National Park Service Wilderness Areas.

Federal land now contains 33 designated natural areas and there are over 170 existing state natural areas. These areas provide examples of unusual flora or fauna types, associations or other biotic phenomena and characteritistics of outstanding geologic, pedologic or aquatic features and processes.

While historical and cultural sites are also an important recreational resource of the Region, these resources are primarily a product of history. In many cases, they have been set aside and are managed so as to make their cultural and historical values available to as many people as possible.

Most surface water areas in the Region are suitable as recreational resources, but several factors must be considered. These include the location of the body of water in relation to population centers and the degree of available access to the water surface together with the size and configuration of the vital strip of land that comprises the shoreline and buffer zone. The quality of the resource for recreation purposes is governed by these considerations.

PART IV - MEANS TO SATISFY NEEDS

In resource planning, comparisons of alternative means of satisfying needs is a vital part of the planning process. In its Interim Report No. 1, the National Water Commission stated,

> "... in spite of the long and costly planning process, the water resources agencies do not adequately consider alternative structures, locations, combinations of facilities, and non-water alternatives for meeting needs."

It is important to be aware of all the various methods available for satisfying needs and meeting requirements. In presenting recommendations, reference should be made to those alternatives rejected (and the reasons for rejection) as well as the selected plan.

This section identifies and describes alternative means to satisfy needs. It discusses both structural and non-structural means to solve problems and meet requirements. Administrative programs and management methods are often as effective in satisfying human needs as are physical structures.

Many of the means to satisfy needs appear to have little direct relationship to the Region's water resources. Nevertheless, these means are important because their selection over other choices may result in reducing the demand on the Region's water resources and thereby produce greater flexibility in water resource planning. Methods of generating electric power or reducing flood damage, or meeting food and fiber needs by imports, all without directly affecting the Region's water resources, may in fact serve other beneficial purposes in that alternative methods might have tended to deplete or degrade the water resources.

GENERAL

Regional needs for goods and services can be satisfied by: a) development and use of the Region's resources; b) more intensive

or efficient use of already developed resources; c) importing the goods and services from outside the Region; or, d) a combination of these. Most resource planning studies are limited in scope to considering only the resource development means. As a consequence, the total range of alternatives are not available for evaluation and decisions are made without the benefit of all choices being analyzed.

In satisfying the needs for food and fiber most are familiar with the process of translating these needs into requirements for water and land resources. Detailed knowledge of the available land resources allows us flexibility in choosing the most productive lands in order to minimize acreage and water requirements. At the same time we must take into account the location of the land resources relative to possible sources of water supply, climatic conditions, distance to market, and competing uses for land. This approach might be described as the resource development method.

In an area such as the California Region, the resource development method can be very complex. There are any number of combinations of land and water resources that could be combined to produce a specified quantity of food and fiber. Results of previous studies, experience, and judgement of planners are components that guide the selection of one or more combinations that appear to be most reasonable and appropriate under an existing or given set of conditions.

Methods that do not require the development of additional water and land resources must be considered in evaluating means to satisfy needs. Food and fiber needs may be more advantageously satisfied by investing more capital into agricultural research, fertilizers, and insecticides in order to increase crop yields than by using larger amounts of land and water resources. This example points out two opposing effects on environmental quality -- that of reducing out-of-stream water requirements

and maintaining the natural land cover against the possibility of increasing concentrations of nutrients and poisons. These effects must be identified, evaluated and weighted against each other -- and not necessarily only in terms of dollars.

Again using food and fiber production as an example, insofar as the California Region is concerned, importing goods and services to satisfy regional needs may be either more or less satisfactory than using regional resources to produce the same goods and services.

Solutions that do not require additional development of water and land resources can be applied to other functional requirements. In some areas, regulation of the use and development of flood plains can effectively reduce flood damages and preclude the need for structural programs such as dams and reservoirs. Similarly, part of the need for resource development to provide M&I water supply can be negated by capital investment in more efficient means to utilize present supplies by industry, commerce, and municipalities.

Historically, non-development of resources has generally not been a justified means of satisfying needs. This was principally because there were sufficient resource supplies to meet most requirements. As resources are committed to specific uses and their availability becomes limited, new and alternative means must be developed.

WATER SUPPLY

Water supply is considered in this study to be a composite function since it is identified as an out-of-stream requirement for five specific functions -- irrigation, municipal and industrial, recreation, fish and wildlife, and mining. The alternative methods of obtaining new water supplies are extremely varied and include the conventional as well as the newer methods. Comprehensive planning

requires that all possible sources of water supply be considered. Table 11 summarizes the potential sources of water supply and the estimated cost range. Each alternative is described below.

Surface Water

Withdrawal of water by direct streamflow diversion is possibly the most basic method of obtaining water supply. An extension of this method involves construction of dams to create regulatory storage capacity on the stream and alternately storing and releasing the stream runoff. The resulting change in streamflow regimen is designed to allow greater withdrawals and is timed to correspond with demand schedules.

The previous section concerning RESOURCE SUPPLY generally covered the present and future availability of surface water. It noted that in 1965 there was a reserve supply of 2.1 million acre-feet per year available and that an additional 7.1 million acre-feet per year would soon be available. The distribution of this water has already been planned and will be essentially as shown in Table 9.

Table 9

PLANNED DISTRIBUTION OF NEW SURFACE WATER SUPPLIES

Subregion	Acre-feet/yr
North Coastal	74,000
San Francisco Bay	865,000
Central Coastal	6,000
South Coastal	1,621,000
Sacramento Basin	2,177,000
Delta-Central Sierra	719,000
San Joaquin Basin	708,000
Tulare Basin	2,712,000
North Lahontan	14,000
South Lahontan	230,000
Colorado Desert	79,000
California Region	9,205,000

For all practical purposes, most of the remaining unregulated surface water supplies are either in the Sacramento Basin or the North Coastal Subregions (Figure 2). Water projects that would develop one million acre-feet per year have been authorized but are currently unfunded. Additional water supply projects have been studied at both feasibility and reconnaissance levels and show that at least 11 million acre-feet of additional developed water supply could be regulated to meet out-of-stream needs throughout the Region (Table 5).

Present estimates indicate that the one million acre-feet of water from authorized projects can be delivered to service areas for an average of about \$30 to \$40 per acre-foot. Additional water supplies, primarily from the North Coast, can be delivered for an average of about \$50 per acre-foot.

In addition to the foregoing, there remains the opportunity to regulate, by long-term offstream storage of at least 7 years, a portion of the winter floods of the Central Valley. Two primary elements are necessary for this regulation -- a large amount of reservoir storage capacity and conveyance capability between the point at which the floodflows might be intercepted and the storage sites. Reconnaissance level studies have indicated that at least 2 million acre-feet per year could be regulated by this means at a cost of about \$30 per acre-foot. Conveyance to service areas of use would be additional.

Ground Water

The possibility of additional ground-water development in the future was not evaluated to any significant extent. Except for approximately 100,000 acre-feet per year in the North Coastal Subregion, it is concluded that there is no additional safe ground-water yield in the California Region. However, there may be opportunities to make more efficient use of the ground-water

reservoirs. This would involve pumping in excess of the safe yield during periods of drought and replenishing the ground-water reservoirs during periods of surplus surface flow by reduction of pumping, deep percolation of surface water applications, and by artificial replenishment. Ground-water storage capacity can be used in conjunction with surface recharge on a planned operation "put and take" basis. This approach is practiced currently in the south San Francisco Bay area, in Salinas Valley, in the San Joaquin Valley, and in the South Coastal area.

Long-term depletion of ground water in storage (mining the ground-water resources) was not considered in this study as a means to satisfy the water development requirements. This is not to say that such a practice should not be considered or evaluated. Ground-water overdraft has been practiced in the South Coastal Subregion and is currently in practice in the Tulare Basin Subregion. Sufficent information is not available at this time, however, to indicate how continued ground-water mining might fit into an overall plan.

Desalting

There is a substantial potential for desalting brackish or sea water in the California Region. Inland sources include the Salton Sea and the agricultural drainage from the San Joaquin Valley. The most likely coastal sites are from Santa Clara County south to the Mexican border.

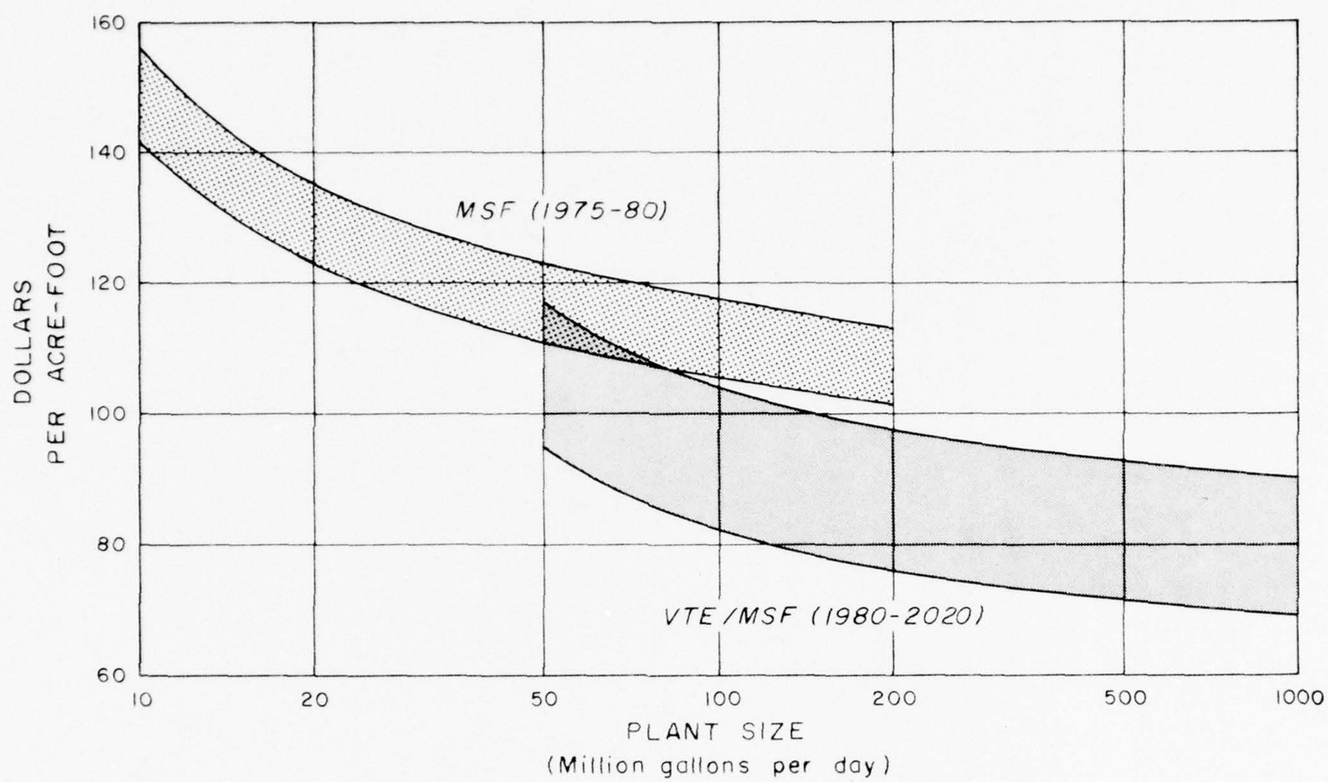
Cost is the major factor limiting present and near future development of sea and brackish water desalting. A 2.6 million gallon per day desalter in Key West, Florida, (1967) produces desalted sea water for about 85 cents per 1,000 gallons ($280 per acre-foot). In late 1968 a 7.5 million gallon per day plant (7,500 acre-feet per year) was completed at Rosarito Beach, Mexico. Desalted water is estimated to cost about 70 cents per 1,000 gallons ($225 per acre-foot). With advances in technology, both

in the desalting process and in power generation using nuclear reactors, the unit cost of fresh water production should decrease.

The Office of Saline Water has prepared a comprehensive summary on the technology and possibilities of desalting. This "Special Report on Status of Desalting", dated November 1970, was prepared for the several framework studies in the Pacific Southwest.

Figure 5 presents estimated cost information from the OSW report. If a large distillation plant were built in the near term, it would probably be of the MSF (multistage flash) process. A recent development in VTE (vertical tube evaporator) conceptual designs has been the use of the multistage flash evaporator to recover the heat from the brine and product streams and heat the incoming feed stream. This approach has the advantage of reducing the cost of heat recovery surfaces. Estimated costs of the multi-effect vertical-tube distillation process with multistage feed heating (VTE/MSF) are also shown in Figure 5. The range of costs shown reflect the differences between private financing (higher interest rate) and public financing, as well as timing.

The water supply developed by desalting can be used to augment existing systems. For those water supply systems in which all usable runoff is collected, stored and beneficially used, the supply can be augmented by a base-loaded desalting plant. For those systems where rainfall and storage are adequate during normal years but severe restrictions may occur during dry years, desalted water could fill the gaps in the natural water supply. A small amount of relatively costly desalted water produced in dry years or during peak demand could firm up a much larger amount of low cost natural water in average or wet years. This type of system, requiring close coordination of desalting plants with natural supply, has been termed "conjunctive use" of desalting.



Source: "Special Report on Status of Desalting" November 1970, OSW.

Terminology: MSF—Multistage flash

VTE—Vertical tube evaporator

FIGURE 5
PROJECTED COST OF DESALTED WATER

Waste Water Reclamation

Reclamation and reuse of waste water effluent offers a means of augmenting present water supplies or making their use more efficient, and assisting in efforts to improve water quality. The greatest potential for accomplishing waste water reclamation is in the populous coastal subregions, particularly the South Coastal area and San Francisco Bay. In these areas large quantities of expensive imported water, some with low mineral content, are discharged to the ocean after only one use. Reclaimed waste water is suitable for irrigation, certain kinds of recreation, industrial use, and ground-water recharge to the extent salt balance can be maintained. Such procedures, as explained later, are currently being practiced.

Interior areas such as the Central Valley, where streamflows are adequate for dilution or where there are natural ground-water recharge opportunities, may not require extensive reclamation of municipal waste water beyond secondary treatment. In such cases reuse of return flows have been considered in projecting requirements for new water supplies.

The Whittier Narrows reclamation facility in Los Angeles County has successfully demonstrated the capability of reclaiming waste water effluent and thereby assists in satisfying increased water requirements. It produces an average of 15,000 acre-feet per year for ground-water replenishment at a cost of about $15 per acre-foot (interest not included).

Tertiary sewage treatment is provided at the Santee Project in San Diego County, and the reclaimed water is used for recreation in four lakes that accommodate boating and fishing, a swimming pool and parks, and irrigation of golf courses, a tree farm, campuses, and crops. A new plant planned for Santee to provide tertiary treatment and limited demineralization will produce 4,500 acre-feet per year of high quality water at an estimated cost of $40 per acre-foot.

It is currently estimated that by 2020 an additional 600,000 acre-feet per year will be reclaimed in the South Coastal area. It is also possible that an additional 300,000 acre-feet of waste water could be recharged to the ground-water basin each year after secondary treatment. If tertiary treatment is provided, including some desalting, an additional 600,000 acre-feet per year could probably be reclaimed and made available.

In the San Francisco Bay Subregion, waste water disposal studies have shown that reclamation and reuse of 500,000 acre-feet annually is a possible alternative to conventional waste treatment and disposal practices. The reclaimed water could be used for a variety of purposes including irrigation, industrial use, recreation, and salinity repulsion. There is also a waste water reclamation potential in the North Lahontan Subregion of at least 10,000 acre-feet per year.

For purposes of framework planning it is not unreasonable to assume that there may be as much as two million acre-feet per year potentially available for waste water reclamation. Based on the 2020 M&I applied water requirements for the South Coastal, Central Coastal, and San Francisco Bay Subregions of 8 to 10 million acre-feet, this is only about 20 to 25 percent of the total use.

Watershed Management

Using watershed management practices, it is possible to maintain or improve water quality through reduced erosion and sedimentation and to influence timing of water delivery. Water yield can be increased in selected areas through control of phreatophyte vegetation, through commercial timber harvest, and through vegetation type conversion. Timing of water delivery may be influenced through snowpack management and forest-cover reduction, and through techniques of management which change vegetative density and species composition. However, whether or not this will effect a

greater net timing change than would be possible by the operation of storage reservoirs alone has not been determined.

The estimated possible future yield increases by treatment of 1.8 million acres of watershed lands vary from 2,000 acre-feet per year in the Delta-Central Sierra Subregion to over 100,000 acre-feet per year in the Sacramento Basin. All together more than 400,000 acre-feet of increased yield could be realized. Table 10 shows the total area suitable for treatment and the estimated resultant increase in water yield following treatment. Both Federal and private lands are included.

Table 10

WATER YIELD INCREASE BY WATERSHED TREATMENT

Subregion	Area (acres)	Increased Yield (AF/yr.)
North Coastal	359,000	94,000
San Francisco Bay	9,000	2,000
Central Coastal	211,000	55,000
South Coastal	376,000	93,000
Sacramento Basin	370,000	105,000
Delta-Central Sierra	9,000	2,000
San Joaquin Basin	103,000	26,000
Tulare Basin	140,000	21,000
North Lahontan	70,000	13,000
South Lahontan	123,000	19,000
Colorado Desert	40,000	5,000
California Region	1,810,000	435,000

Phreatophyte Control

Phreatophytes are those plants that normally obtain their water supply from the zone of saturation, either directly or through the capillary fringe. They occur generally along stream banks, unlined canals, flood plains, and in the delta areas at the heads of reservoirs. During the growing season they satisfy their needs for water by drawing on the ground-water reservoir or from the adjacent body of water.

Methods used to control or eradicate phreatophytes are either mechanical or chemical. Replacement vegetation for erosion control, forage, wildlife, and other uses must be provided on some treatment areas following control measures.

Control or eradication of phreatophytes can result in increasing the Region's water supply, particularly in the arid subregions, but considerably more research and study is needed in the Region to identify the total potential for improving water supply through phreatophyte control.

Weather Modification

Weather modification is an operational tool that can result in new or additional water for a river basin. Management techniques such as timber management, brush treatment, channel treatment, and evaporation suppression represent attempts to conserve or salvage water that is already in the basin. Weather modification, on the other hand, produces runoff from precipitation that normally would not have fallen on the basin. It can therefore be considered as a water source not previously available.

The regulation and modification of natural precipitation by artificial methods has been studied for about 20 years as a possible means of increasing water supplies. Full effectiveness of the process is still uncertain, but because the cost of cloud-seeding is small relative to the possible benefits, it is widely practiced in the Region by county agencies, water conservation districts, and power companies.

Increases in runoff to be expected from artifically enhanced precipitation are relatively large. A 5 percent increase in precipitation may result in a 7 or 8 percent increase in runoff. This is roughly the magnitude of basinwide increases in runoff that have been experienced in cloud-seeding projects in California.

The cost of additional water is lower than that of any other artifically produced supply. At present, estimated costs of well-managed programs average between \$0.50 and \$1 per acre-foot.

Development of seeding techniques over the years has resulted in more efficient operation of weather modification projects. However, more research is needed, particularly in developing a better understanding of the physical mechanisms of precipitation. This understanding should lead to more reliable identification of the circumstances under which precipitation might be stimulated artifically, and to improved techniques for performing this stimulation.

All the aspects -- legal, social, and economic -- must be recognized when weather modification is considered for use as a means to increase water supplies. Assuming that a change can be effected raises the question of whether or not the change is desired by all groups concerned. There may be ecological and legal problems with respect to damages from weather modification. Institutional questions arise pertaining to jurisdiction for management, control, and water rights.

Evaporation Reduction

There is evidence that it is feasible under favorable conditions to save water by reducing evaporation from ponds, lakes, and reservoirs. However, technical problems exist and work continues on improving the techniques for applying, maintaining, and evaluating the effectiveness of evaporation retardents on water surfaces. Mono-layer-forming materials have received considerable attention and have been used in the form of solid chunks, flakes, finely divided powders, molten sprays, solutions, and emulsions to form monomolecular films on the water surface. While each form has been found to have advantages and disadvantages, none has proved to be a panacea for solving the problems encountered in field application, particularly that of maintaining a film on the water surface in the presence of wind or waves.

Improve Existing Project Operation

Water supply development was discussed in PART III, RESOURCE SUPPLY. It was reported that the present developed water supply of 36.8 million acre-feet per year will increase to about 40 million acre-feet per year when projects currently under construction are completed, ground-water overdraft is eliminated, and diversions from the Colorado River are cut back by 500,000 acre-feet per year.

Water project operating criteria have been developed over a period of years to take into account the variable features of climate, rainfall and runoff, and the special situation of each water service area. Generally, it has been the practice of water supply planners to theoretically operate proposed facilities through a historical critical period of time during which the natural streamflow was lowest. Operating criteria are thus developed to ensure the firm supply of a given amount of water each year during such a period, usually allowing for some predetermined deficiency in supply for any one year or group of years during the period.

It appears reasonable that (comparing statistically economic gains from various higher yields and the potential losses from corresponding deficiencies) the presently available developed surface water supply could be operated to increase the effective yield. Improved hydrometeorological forecasting will be an important contribution to the operation of water supply systems and should bring about greater efficiency in the operation of water control facilities. Use of satellites, such as the Nimbus III carrying numerous weather measuring instruments, has added to this capability. In summary, a combination of improved operating criteria for individual projects and better coordination of the various water supply projects in the Region should result in the more efficient use of available water resources. An estimate of the expected increase is not available at this time.

Geothermal

Following the passage of the Geothermal Steam Act in December 1970, the USGS initiated a study to classify all potentially productive geothermal land. The small amount of geothermal development in the past has largely been related to electric power production. However, recent exploration of the geothermal zone underlying portions of the Imperial Valley has indicated an enormous potential as a possible source of fresh water.

A 1970 report by Dr. Robert Rex, of the University of California at Riverside, described recent investigations of the geothermal potential of the Lower Colorado River Basin. The results of these investigations suggest that a possible major source of augmentation to the Colorado River's flows can be developed in the Imperial Valley as a co-product of geothermal power. The investigations concentrated on the Imperial Valley but report that an area estimated at 2 million acres, comprising the Lower Colorado River delta area, portions of Arizona and Nevada, and extending into Mexico, is a geothermal regime which may be commercially exploitable through combined projects yielding some mix of steam power, desalinated water, and mineral and metals recovery.

Studies made to date indicate that from 4 to as much as 10 million acre-feet of fresh water per year for 100 to 800 years might be distilled from the geothermal brine available in the Imperial Valley area. Cost range is presently estimated at $50 to $80 per acre-foot for water from a multipurpose development. Depending on the actual system devised, output might be limited to only enough water to dilute and minimize salinity of present Colorado River supplies or the output might provide major augmentation.

In conjunction with a geothermal program, there are several possibilities. Brine could be pumped back into the hot water aquifers to recharge them; water could be drawn from the Salton

Sea for distillation, thus stabilizing the Sea at a lower elevation and constant salinity; a saltwater port at Yuma might be built; providing a large water source for hot water aquifer recharge.

In a 1968 report, principal barriers to development were listed as: (1) lack of knowledge of the extent and engineering properties of the brine, leading to (2) lack of knowledge of the economic value of development, and (3) lack of legislation and precedent for this type of development. As previously indicated, legislation was enacted in December 1970 and studies have been initiated. At present, very little of the sort of geophysical data required for engineering and economic analyses of specific projects are available. Investigations presently conducted are funded primarily by the Bureau of Reclamation and involve the University of California at Riverside and the Office of Saline Water. A study grant is to be expended over a period of several years and is geared to reconnaissance level studies of geology, thermal conductivity and chemical composition, and areal distribution of the steam.

It is generally known that from place to place, there are wide variations in the hot brine that might be available, its depth, extent, temperature, pressure, salinity, and corrosiveness. To date Imperial Valley brines have been highly saline and highly corrosive, not readily amenable to desalination or to power production. At present, brine disposal problems have not been solved, preventing commercial power development at existing wells in the Imperial Valley.

Reduce Irrigation Requirements

If, by reducing crop irrigation requirements or increasing irrigation efficiency, the same level of agricultural production could be achieved with less applied water, a corresponding reduction in the amount of water developed could be realized.

Irrigation efficiency is defined as the relationship between "consumptive use of applied water (crop irrigation requirement)" and "applied water". Irrigation efficiency can be increased by measures that reduce amounts of applied water and, in turn, evaporation loss, deep percolation, and surface runoff. Field efficiency in this study is estimated to be about 70 percent which means that for every 10 acre-feet of applied water, 7 acre-feet are consumptively used for crop production and the remainder is lost to evaporation, deep percolation or runoff. (The runoff portion is available for reuse in most areas and as a result the service area efficiency may be in the order of 80 percent or more.)

Crop irrigation requirement is the quantity of water that must be furnished to the crop by irrigation. The crop irrigation requirement can be reduced through methods that reduce total consumptive use such as reducing the amount of water use to build plant tissue, reducing transpiration by the plant, or reducing evaporation from the adjacent soil during the growing season.

Better water management, improved cultural practices and increased use of sprinklers or trickler irrigation are examples of ways to reduce irrigation requirements through increasing irrigation efficiency.

Import Goods and Services

Projected needs for goods and services can be met in two ways -- from those produced in the Region or from those imported into the Region. Yet, few analyses consider the importation of goods when estimating production requirements.

Several questions should be examined. What would be the effect of importing certain goods? What happens to regional growth, social well-being, and environmental quality? Some of the answers to these questions are provided in Appendix IV. This discussion outlines some of the impacts of importing feed grains, livestock and meat products.

Based on regional comparative advantage and the principle that farm managers respond to economic forces in a way that tends to maximize their net income, it can be shown that there is possibility for a substantial reduction in water requirements with relatively little impact on employment, income, or net returns. This could be accomplished by reducing the production of livestock feed crops (alfalfa, irrigated pasture, corn, barley, grain sorghum, silage, etc.) and importing either the feed, livestock for slaughter, or meat products. It should be emphasized that this approach affects the economic activity of a relatively small part of the Region's agriculture. For example, comparative advantage and transportation costs indicate it would probably not be to the Region's advantage to reduce projected milk production. And, of course, there would be no effect on any of the many fruit, vegetable, and other crops for which the Region clearly has a comparative advantage over other regions.

Some of the facts that indicate the feasibility of these alternatives are as follows: California produces only about 2 percent of the feed grain in the United States. In the 1961-65 period, 49 percent of the feed grain used in the Region was imported. Of the total regional beef supply in 1964, 64 percent was produced in California, 14 percent was from livestock shipped in for immediate slaughter, and 22 percent was imported as meat products. For pork supply, 2 percent was produced in California, 21 percent was shipped in as livestock for slaughter and 77 percent in meat imports.

Base Plan and OBERS projections show the California Region using about 15 million acre-feet of water in 2020 to produce livestock feed, including irrigated pasture, and Series D-1970 about 20 percent less. The following tabulations show two examples of the impacts of reducing irrigation requirements by 5 million acre-feet in 2020 for Base Plan projection.

Example 1

IMPORT FEED GRAIN OR HAY

	Amount Reduced	Percent of Regional Total
Water Requirements (1,000 AF)		
Feed sectors	4,978	8.95
Other sectors	22	0.04
Total	5,000	8.99
Gross Regional Product ($ million)		
Feed sectors	218	0.034
Other sectors	139	0.022
Total	357	0.056
Employment (number of persons)		
Feed sectors	3,704	0.016
Other sectors	2,421	0.011
Total	6,125	0.027

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Example 2

IMPORT LIVESTOCK

	Amount Reduced	Percent of Regional Total
Water Requirements (1,000 AF)		
Livestock sectors	60	0.11
Other sectors	4,940	8.88
Total	5,000	8.99
Gross Regional Product ($ million)		
Livestock sectors	921	0.145
Other sectors	772	0.122
Total	1,693	0.267
Employment (number of persons)		
Livestock sectors	7,422	0.033
Other sectors	12,796	0.057
Total	20,218	0.090

The reduction of 5 million acre-feet of applied water reduces water requirements[1/] by around 9 percent, but gross output and employment would drop less than 1/20 of 1 percent when feed crops

1/ For this example, only applied requirements are considered.

are imported and less than 1/5 of 1 percent when livestock is imported.

Thus clearly, if other water supply alternatives are costly or if they have important secondary impacts such as adverse environmental degradation, the alternative of importing some of our needs can result in substantial water saving with relatively minor losses in income and employment. Implementation of a policy to import high water using commodities in our free economy would have to be through the economic system. Other regions would need not only the productive capacity but also the economic incentive to produce the additional livestock or feed.

While the above analysis clearly indicates the relatively small economic loss from importing low value high water using commodities, it does not provide all of the information needed to compare it to other alternatives. What is needed is a measure of the impacts of producing in the California Region as compared to alternative locations. In addition to the water requirements, employment and gross regional product impacts in each region, the costs of production and distribution, and all environmental or quality of life impacts are also needed. The required studies are identified in the PLAN OF ACTION portion of this report.

Increase Crop Yields

Crop yields projections made for the California Region framework study show individual crop yields increasing by 27 to 140 percent (81 percent average) between 1965 and 2020. These increases have the effect of reducing 2020 irrigation water requirements by more than 30 million acre-feet over what would have been necessary to produce the same quantity of food and fiber with 1965 yields. This estimate is based on the assumption that the average water use per acre does not increase as yields increase. While it might be expected that for certain crops water use per acre would increase over time, for other crops water use might decrease. In

addition, the increases in projected yield would require more effective application methods that would tend to reduce water requirements.

No specific assumption is made about the level of programs needed to achieve these higher levels. They were arrived at by a statistical analysis of yield trends modified by the judgement of university commodity and extension specialists. Future yields are expected to be influenced by changes in plant structure, insect and disease control, fertilizer and chemical application, and improved cultural practices.

Changing plant structure includes the development of new varieties (e.g., hybrids, dwarf, double dwarf, and triple dwarf varieties). Technology affecting plant structure holds promise of large impacts on crop yields. Technicians generally feel, for example, that even the recent large increases in grain sorgum yield reflect only the "first generation" of hybridization, and further improvements are inevitable.

Pathogens and insects currently have a severe impact on yields. Estimates of annual crop loss due to insects and disease run as high as 30 percent. Discovery of new controls will likely have a major impact on future yields. Systemic disease controls show substantial promise. Restrictions on the use of certain insecticides, such as DDT, will likely have more impact on the cost of insect control than on the effectiveness of control. Discovery of new fertilizers is not expected. However, development of more effective growth regulation chemicals may be important.

Even if there were no new advances in the factors mentioned above, many of the projected yield levels could be attained by improvements in management alone. As new technology expands the range of choices available to farm operators, farm management decisions become more complex and more important. While the optimum combination of resources does not necessarily mean higher yields, the tendency is in that direction.

A 25 percent increase in the projected 1965-2020 growth rate of crop yields (over and above the 27 to 140 percent projected increases previously mentioned) would result in a decrease in irrigation water requirements of 6.5 million acre-feet of water annually. Benefits from such an increase would be several. In addition to the savings in capital costs for developing water supply, less land would be required for irrigation allowing other uses of that land or saving it for future agricultural use. Net returns to agriculture would also increase, reflecting the lower cost per unit of production. No dollar estimate of this value of an assumed yield increase is available.

Estimates are not available of the investment in research, development or management required to increase yields faster than the projected rate. In fact, there is no assurance that the projected yields used in the study will be attained. However, yield increases are very important in meeting future needs and the capability of programs or policies to increase yields needs to be evaluated.

Reduce M&I Per Capita Use

In 1965 per capita use of municipal and industrial water in the United States and California was 157 and 204 gallons per day, respectively.[1/] Demand in 2020 is projected to increase to 170 gpcd nationally and to about 240 gpcd for the California Region. If the regional per capita use did not increase beyond the 1965 level, between 1.5 and 2.0 million acre-feet of new water supply would not have to be developed. It might be possible to have the same high standard of well-being that is projected for 2020 without a significant increase in per capita demand.

1/ 1968 National Assessment, Water Resources Council, Washington, D.C.

Methods of reducing municipal and industrial water use include education, metering, tax incentives, and pricing. In addition, improved efficiency and technology will also reduce M&I water use. Holding per capita requirements to 204 gallons in 2020 would still make California 20 percent higher than the nation as a whole. Comparing the California Region with nationwide averages is only used herein to gain an overall perspective. Within the Region, per capita use presently varies from 170 to 390 gpcd (San Francisco Bay and San Joaquin Subregions). It is projected by 2020 to vary from 200 to 390 gpcd with most of the subregions with low per capita use showing an increase.

Table 11

POTENTIAL AND COST OF WATER SUPPLY
AND WATER REQUIREMENT REDUCTION MEANS
CALIFORNIA REGION

Plan Element	Potential (1,000 AF/yr	Estimated Cost Per Acre-Foot	Confidence Rating a/
Surface water	12,000 b/	\$30 - \$50	A
Ground water	Interim use only	Varies with depth	A
Desalting	Large	\$70 - \$150	B
Waste water reclamation	2,000	\$15 - \$40	B
Watershed management	435	Combined with land treatment	B
Phreatophyte control	Uncertain	--	C
Weather modification	Uncertain	--	C
Evaporation reduction	Uncertain	--	C
Improve existing project operation	No estimate	--	C
Geothermal	Large	--	C
Reduce irriga- tion require- ment	Small to moderate	--	C
Import goods and services	Moderate to large	--	B
Increase crop yields	Large	--	C
Reduce M&I unit use	1,500 to 2,000	--	B

a/ Confidence rating code:

A - Acceptable for planning.
B - Estimates available, but considered tentative, some additional information needed.
C - No acceptable estimates available, considerable additional information required.

b/ Does not include 9.2 million acre-feet of assured projects.

LAND MANAGEMENT

The land management function is concerned with (1) maintaining or increasing the productivity of our land resources, and (2) protecting or reducing damages to the land resources. Land treatment measures are designed to improve production from irrigated and non-irrigated cropland and pasture, forest and woodland, and rangeland. These measures are also intended to prevent or suppress wildfire and to reduce erosion and sediment damage.

Crop Production

One method of satisfying future needs of a growing population for food and fiber is to place major emphasis on increasing crop yields. Increasing yields in lieu of increasing the need for more land and water is discussed earlier in this section where it is stated that crop yields in the Region are projected to increase by 27 to 140 percent. Land management activities that would assist in this increase include: (1) on-farm water application and drainage improvement measures such as land leveling, the installation of sprinkler systems, irrigation pipelines, surface and tile drainage systems, and the lining of irrigation ditches; (2) cultural measures for crop production such as contour farming, cover cropping, crop residue use, and minimum tillage; (3) management measures for crop production such as improved irrigation efficiency and the selection of crops adapted to land capability.

Forage Production

Management programs are aimed at protecting the capacity of the land to produce forage as well as increasing the amount of useable forage. Measures employed to achieve this aim are the regulation of livestock grazing through fencing, reseeding, fertilization, development of water facilities, and adjustment of numbers of livestock and length and season of use. Wildlife management is also practiced by controlling numbers of game animals

through the regulation of season and harvest and by maintaining or improving game habitat. This use of the forage by livestock and wildlife, when properly regulated, can help to maintain an adequate vegetative cover as well as improve the productive capacity of the land.

Timber Production

The Region's demand for timber products exceeds the regional production, a condition that will become more acute in the future. Consideration should therefore be given to increasing the productive capacity of the Region's timber lands. Those lands capable of producing high wood product yields could be intensively managed through measures such as reforestation, irrigation, fertilization, thinning, intermediate cutting and full utilization of the wood fiber produced. Those lands which have been identified as meeting other needs such as recreation sites, wilderness areas, and residence tracts, should be removed from the commercial timber production classification. Dispersed recreation use and increased water yields will continue to be major elements in forest land programs for meeting population needs.

Erosion and Sedimentation Damage

Erosion is the dislodgement and removal of surface material by running water and wind causing the loss of soil and land productivity, and damage to public facilities and farms. Sedimentation is the subsequent deposition of the eroded material and can occur in flood plains, stream channels, reservoirs, navigation facilities, and urban areas. Erosion and sediment production can be reduced by measures broadly described as "management," "land treatment," and "structural." Management measures emphasize proper uses of the land and related resources to minimize erosion and sediment yield. Land treatment measures are aimed at holding the soil in place, including reduction in rainfall impact and runoff and increasing

the resistance of the soil to erosion through improved vegetation cover. Structural measures retard erosion at the site and provide a trap for sediment moving into an area from upstream.

<u>Wildfire Damage</u>

Damages from wildfire include destruction of valuable timber, crops, and grasslands, losses of homes, businesses, and other improvements; and, increased erosion and sediment from burnt-over areas. Wildfire damage reduction programs include education of the public, maintenance of effective fire-fighting forces, and construction of fire fuel breaks.

<u>Watershed Protection Projects</u>

Upstream watershed protection projects generally are not large, expensive, or particularly glamorous, but are designed to provide flood and sediment prevention by land treatment, structural, and management measures. They slow down or impound waters in the upstream watershed to prevent excessive and rapid runoff or flooding.

Typical treatment, management, and structural measures to improve production and decrease damage include:

Proper grazing use	Fertilization
Brush control	Proper cropping use
Proper timber management	Debris basins
Reservoirs	Fire prevention & suppression

Revegetation to grass, shrubs or trees
Proper road construction and maintenance
Grassed waterway or outlets

RECREATION

The means to satisfy recreation needs takes many forms. They include, but are not limited to, such measures as acquiring new lands, providing new access to existing lands and water areas,

zoning of existing lands, facility development, providing incentives and mechanisms for opening lands in private and public ownership to recreation, multiple use of facilities such as education buildings and grounds and parking lots, providing open space by acquisition and land use practices, preserving free flowing streams, natural and wilderness areas and preserving historical and archeological values.

Land Acquisition

Land acquisition goals include: (a) acquisition of inholdings and other lands adjacent to present recreation areas to control future development; (b) acquisition of lands in urban areas to meet intense demand for classes I and II recreation resource opportunity; (c) preserving the most significant examples of California landscape, including the coastline; and (d) creating a chain of parks along rivers of the Central Valley and the Lower Colorado River. Riding and hiking trails are a feature that should receive high priority.

Access

People seek recreation in those parts of the Region nearest their homes and those living in deprived urban neighborhoods are least able to meet their needs. Access then becomes a constraint to satisfying recreation needs. The solution to the problem calls for either recreation areas and facilities to be located nearby or providing inexpensive mass transportation to the distant areas.

In other parts of the Region, land recreation areas have a latent potential that could be realized by providing more access or improving the existing access routes. Straightening routes would provide easier access to recreationists who wish to tow boats or bring other specialized recreation vehicles to areas catering to their specific needs.

Zoning and Land Use Practices

Recreation land acquisition needs will be the greatest in urban areas. Recreation will be forced to compete with other uses for prime lands. Zoning regulations at the local level, implemented in concert with State land use policies, could assure that recreation lands would be available when needed.

Development

Development to meet future recreation needs must recognize definite goals such as those proposed by California Department of Parks and Recreation. Several vital goals for the Region's recreation development should include: (a) seeking more active involvement of users and user groups in planning and designing facilities, (b) recognizing increased use of specialized vehicles, (c) providing a wider range of overnight accommodations, especially hotels and dormitories for youth groups, (d) placing greater emphasis on facilities attractive to young people, especially teenagers, (e) extend the use of parks by providing activities for all seasons, (f) expanding the role of private capital to develop more deluxe type of accommodations, (g) developing a system of enroute (one night stop) camping facilities for vacationing families, (h) developing regions to give youth a knowledge and respect for environment, (i) developing dormitory facilities adjacent to selected natural areas for use of educational groups, (j) designing self-guided trails and/or interpretive exhibits at all natural areas and historic units.

Opening Closed Watersheds and Reservoirs

The opening of closed watersheds to public recreation offers outstanding opportunities to expand the supply of badly needed water recreation areas. Thousands of acres of land and water are presently fenced off from use by the public. Incentive should be provided for private landowners to open their potential recreation

lands to recreation use. More attractive tax benefits and freedom from liability, and preferential assessment, or tax exemption should all be explored as inducement to opening presently closed lands. With regard to terminal domestic water supply reservoirs, the Pacific Southwest Inter-Agency Committee has recommended opening these reservoirs and contiguous areas for recreational use, consistent with existing health regulations.

Multiple Use of Existing Facilities

The scarcity of undeveloped lands, particularly in cities, makes the single purpose use of land extremely expensive. A more feasible approach would be mandatory agreements at the local government level that there be joint development and use of existing land and facilities. Examples of this multiple use would be schools, renewal and development projects, freeway and rapid transit rights-of-way. Irrigation conveyance structure routes, transmission and other utility lines, airport and seaports could also provide joint and multiple use of certain facilities or lands.

Providing Open Space

Dedicated open space is necessary in built-up areas to assist in preventing urban sprawl and to preserve land for other purposes. It is needed in the remote areas for those wishing to have a place to escape the clamor of the cities. Preservation of open space permits the continued use of land for agriculture, timber, mining, watershed, wildlife, recreation and related purposes, and at the same time maintains a desirable balance of environmental and esthetic quality within an expanding municipal and industrial area.

Preserving Free Flowing Streams

Reaches of 26 streams have been identified by framework studies as worthy of study under Section 5(d) of the Wild and Scenic Rivers Act. The Middle Fork Feather River has been designated as a "Wild

and Scenic River." Six additional streams are being considered as first priority additions to the National Wild and Scenic River system and are under study for potential inclusion in the system. These are: Smith River; Klamath River -- Iron Gate Dam to ocean; Sacramento River -- source to Clarksburg; Russian River -- Ukiah to mouth; Tuolumne River -- Lunsden Bridge to Ward's Ferry and below LaGrange Dam; and, Kern River -- above Lake Isabella.

Many of these free flowing rivers and streams within the Region are in direct or indirect conflict with various proposals for water development and flood control. These conflicts can only be resolved after intensive studies and research.

FISH AND WILDLIFE

Fish and wildlife are dependent upon the air, land, and water resources. Availability of suitable habitat is a critical limiting factor in maintaining fish and wildlife. Satisfying the needs of a growing human population for land and water has resulted in a steady decline and alteration of the wildlife habitat. Water regulation and diversion projects have increased reservoir habitat and have both increased and reduced stream habitat.

The greatest potential for increasing the supply of fish and wildlife species lies in on-going programs of State and Federal wildlife and land management agencies which include: accelerated hatchery production, spawning channel construction, stream spawning area rehabilitation, streamflow augmentation or improvement, food cover planting, access improvement, biological control, and maintenance of flexibility of bag limits and length of season. Additional benefits would accrue to wildlife from expansion of production, resting, and feeding areas; enlargement of winter range carrying capacity, and creation of sanctuaries or refuges for rare and endangered species.

Properly planned multipurpose water projects, improved forest and range management practices, open space programs, and pollution

abatement measures can all assist in improving the fish and wildlife supply.

WATER QUALITY

Water quality problems principally result from concentrated population and industry in the San Francisco Bay and South Coastal Subregions, irrigated agriculture in the San Joaquin, Tulare and Colorado Desert Subregions, and generally low summer streamflows throughout the Region. All alternative means, such as water treatment, streamflow augmentation, and other methods, to meet the water quality needs of the various identified uses should be examined in an integral fashion with the meeting of water quantity needs to determine the most favorable overall approaches from economic, environmental, and other aspects.

Treatment

Collection and treatment of municipal and industrial waste and safe disposal of the effluent are considered to be the most effective methods of reducing water pollution and protecting water resource quality. Two important prerequisites to implementing treatment of waste water are the establishment of water quality standards and the active enforcement of pollution control laws.

Reclamation

An extension of the waste water treatment method is to provide sufficient treatment so that the waste water can be beneficially reused. As our water resources become scarcer, this means of water quality control will also serve the purpose of water conservation.

In the past, several factors have limited the potential reuse of waste effluent. They include economics, high cost of treatment and low cost of alternative water supplies, and public aversion to reusing waste water. The situation in recent years has changed

and the public is now more aware of the problems we face concerning water resource supply and the fact that they cannot distinguish between virgin water and that which has been used several times and then reclaimed. Municipal and industrial water use in the coastal subregions will range from 8 to 10 million acre-feet by 2020. Since as much as one-half of this amount may occur as return flow, it could be discharged into a bay or the ocean and thereby lost to further use unless it is captured and reclaimed.

Dilution

Augmenting streamflow must be considered as a method for solving water quality problems, particularly when the quality problem is one of natural causes or has been brought about by low flow conditions.

Management

Land use management or zoning practices can be used to help prevent pollution. Feed lots or solid waste dumps must be carefully located so that drainage from these areas does not enter the surface or ground-water supplies.

Land treatment measures are another form of management that can be used to overcome natural causes of pollution. Erosion control to reduce sediment is the most common form of this concept.

The need for water quality management programs should be considered for inclusion in formulating and evaluating all resource development projects. Such programs may provide an economical solution and it may be possible to operate water regulation facilities in such a manner that concentration of mineral constituents, temperature, and dissolved oxygen levels are improved for beneficial uses.

Industrial Practices

The modification of industrial practices could be instrumental in reducing pollution. One of the most common future pollutants could be the discharge of heated water. If problems are created by thermal pollution the use of cooling towers would reduce both the need for diverting large quantities of cooling water and the subsequent return of the same water at a higher temperature.

FLOOD DAMAGE REDUCTION

The basic objective of a flood control program is to contribute to the overall well-being of the people by reducing loss of life, human suffering, damage to real property, and loss of goods and services. Flood damage reduction measures can be broadly classified as structural, consisting of dams and reservoirs, levees, and channel improvements; and non-structural, including watershed treatment, regulation of flood plain use, and flood forecasting and warning systems.

Dams and Reservoirs

Flood protection can be achieved by storing floodwater in reservoirs and releasing it at rates that are within the capacity of downstream channels. Such storage may be of a very temporary nature where releases are through uncontrolled outlets. At reservoirs with controlled outlets, the stored waters may be held for long periods of time depending upon the downstream flood situation or upon need for conservation of the water.

Reservoirs, as a means of surface water regulation and flood control, are perhaps the most versatile from the standpoint of comprehensive river basin development. Reservoirs which reduce floodflows may be used to provide water supply, generate power, improve water quality, and provide opportunities for public recreation and for enhancement of fish and wildlife. In brief, reservoirs constitute a basic facility for multiple-purpose river development.

Levees

Confinement of floodwaters is one of the oldest and a very effective means of reducing flood damages. This is most often achieved by the construction of earth levees, or dikes, to keep the floodwaters from spreading over an entire flood plain. Large areas of the original flood plain of the Sacramento River have been protected from overflow by this means. Levees are also frequently used for the protection of cities. In some instances, floodwalls of reinforced concrete are used instead of levees because of the high value lands in urban areas.

Channel Improvement

Another often used means of reducing flood damages is the enlargement of channels. Such enlargement reduces flood stages and flood overflow areas. This can be accomplished by excavating to increase the depth or width (or both) of the natural channel. Channel capacity may also be increased by reducing the resistance that obstructions offer to flow. This is accomplished by removing "snags", phreatophytes, riparian vegetation, and other obstructions, providing a more uniform cross section, and eliminating unnecessary bends. When protection of high-value areas is involved, the resistance to flow may be reduced by providing a smooth channel lining. This measure is exemplified by the concrete channels which carry floodflows through Los Angeles and its suburbs. Such channel linings also serve to protect the channel against erosion by the high velocity flows which a reduction in resistance to flow often induces. Another means of reducing flood stages and flood overflow is by the provision of an alternative channel which comes into play only during great floods. This measure is exemplified by the "floodways" provided at certain points in the Sacramento Valley. These floodways do not come into action until specific flood stages are reaches and gates are opened or fixed weirs are overtopped.

Watershed Treatment

Cultivation, grazing, and the removal of forests, together with other activities of man in the watersheds, have changed runoff characteristics and increased the magnitude of floods. Land treatment measures, consisting of reforestation and soil conservation practices, increase the rate at which precipitation will infiltrate the soil and also increase the capacity of the soil mantle to retain infiltrated water. While these effects are small when compared to the intensity and magnitude of storms that produce the larger floods on major rivers, the increased infiltration may substantially reduce the peak flows in many upstream areas resulting in decreased flood damages.

Regulation of Flood Plain Use

Regulation of flood plain use does not attempt to reduce or eliminate flooding but is designed to mold the flood plain development in such a manner as to lessen the damaging effects of floods. This demands the adoption and use of legal tools by the states and local governments with which to guide and control the extent and type of development which will be permitted in the flood plains.

High hazard areas can be set aside, or "zoned" for such uses as stream-front parks, agriculture, or other low-damage uses. In some instances, buildings can be permitted in such zones if they are "flood proofed" by raising the lowest floor above flood stage or by providing for quick closure of all building openings during floods. The stream channel and those portions of the flood plains adjoining the channel which are reasonably required to carry flood waters can be designated as a "floodway" and no construction or land filling permitted therein that would interfere with the floodwaters.

Flood Forecasting and Warning System

Reliable, accurate, and timely forecasts of floods and flood stages can be coupled with timely evacuation to save lives and reduce property losses. This is particularly applicable to the larger river valleys and lowest reach areas. When it is known that a large flood is about to descend, people move to higher ground, taking such of their belongings as they find it possible to move, and do whatever is possible to minimize damage to the properties which cannot be moved.

Flood Insurance

The National Flood Insurance Act of 1968, by requiring communities to take certain actions in order to be eligible to participate in the insurance program, is a positive step towards reducing flood damage. Community requirements include: (1) restricting development of land subject to flood damage, (2) guiding development of proposed construction away from flood plain areas, (3) assisting in reducing damage caused by floods, and (4) improving the long range land management and use of flood plain areas.

NAVIGATION

Commercial

Means to satisfy future needs for commercial navigation include the expansion of deep-draft harbors, construction of coastal harbors to meet the needs of light-draft commercial vessels, extension or enlargement of inland waterways and extension of private offshore petroleum terminals into deeper waters. Also required are ancillary features to those listed, such as channels, basins and anchorage areas, breakwaters and jetties, berths and cargo-handling areas.

Recreational

Means to satisfy future needs for recreational navigation include construction of new multipurpose harbors within which berthing, launching and transient facilities would be provided; expansion of existing multipurpose harbors, construction of single-purpose harbors of refuge; and development of additional facilities for recreational boats in protected areas of existing navigable waters.

SHORELINE PROTECTION AND DEVELOPMENT

Shoreline Protection

Shoreline damages are caused by the erosive action of waves and consist of loss of beaches and oceanfront land and damages to improvements along the oceanfront resulting therefrom. Damage reduction measures can be either structural or non-structural in nature. Structural measures include such works as stabilization and beach fill, seawalls and revetments, and periodic replenishment of existing beaches. Non-structural measures include the zoning and regulating of shoreline uses to preclude development that might suffer damage.

Shoreline Development

The development of the shoreline for recreational purposes involves the construction of new beaches, the acquisition for public use of beaches and scenic shoreline. Beach areas are often created incidentally to a structural protection program.

ELECTRIC POWER

The two most common means of generating electric power in the California Region have been hydroelectric plants and fossil fuel steam-electric plants. While these methods will continue to be used, nuclear fuel steam-electric and gas turbine thermal plants will become increasingly important as a means of meeting future needs.

Hydroelectric

In 1965 the installed capacity of hydroelectric plants was 5,330 megawatts (MW). By the year 1980 there is a potential for increasing this by 4,690 MW, by year 2000 a potential for 2,900 MW more, and by 2020 an additional 3,190 MW is possible. Full implementation of this 10,780 MW potential is dependent on major water regulation structures in the North Coast, particularly on the Klamath and Salmon Rivers. Development of these rivers for export water supply would require more power than might be produced, and, therefore, their potential for furnishing hydroelectric power would have little net effect on the overall regional production.

When system demand increases at a rapid rate, it has been the practice in mixed electric power systems for the older base-load steam plants to operate at lower capacity factors and for hydroelectric plants to operate for sharp peak and frequency regulation because of their fast response time. Because hydroelectric power will become a smaller portion of the total power resources, its quick response peaking capacity will become more valuable. New hydroelectric plants will undoubtedly be constructed for operation at lower plant factors and existing plants may be enlarged to provide additional peaking capacity. Enlargement of existing plants is not included in the aforesaid hydroelectric potential.

Pumped storage is a special application of hydroelectic power that capitalizes on the peaking value of power. Its potential is partially reflected in the foregoing values where it is now planned in specific projects such as the State Water Project. Other pumped storage opportunities exist and in some cases their potentials are being assessed.

Thermal Electric

Use of a heat source to generate steam and hot gases which expand in an engine or turbine to drive an electric generator is

the major form of thermal electric power. It is generally divided into categories by its fuel sources such as fossil, nuclear, and geothermal.

Fossil Fuel Plants

Fossil fuel plants, mostly steam producing, are currently the most common means of generating base load electric power, and in fact, generate over 80 percent of all electric energy produced in the United States. The total installed capacity of fossil fuel plants (including gas turbines and diesel-electric plants) in the Region was 15,258 MW in 1965. An additional 256 MW of thermal-electric plants, classified as "industrial plants" were also in existence. These industrial plants do not serve the regional load and are not included as electric power resources in the Region. Modern steam plant characteristics have improved in efficiency and reliability and have the advantage of operating at any desirable plant factor and being able to burn a variety of fuels. Use of low sulphur fuels together with electric precipitators and tall stacks can assist in minimizing air pollution, but a satisfactory means of removing sulphur oxides from gases is not yet available. There are however, several technologies currently under investigation that show promise of removing sulphur oxides from flue gases to an acceptable limit. In the future, many steam electric plants will be designed and built especially as peaking plants. These plants permit greater capacity in a single generating unit than either gas turbines or diesel units.

Gas turbines have a quick-start capability and are relatively low in construction costs. However, because of their high operating costs, they are basically restricted to short periods of operation to meet peak loads and provide standby reserve. A problem of locating gas turbines near load centers or populated areas is the noise factor. Diesel engine generators offer the same advantages

and disadvantages as gas turbine plants. They are superior when used for serving small general loads and inferior for large capacities.

Nuclear Powerplants

Nuclear powerplants are much like conventional steam plants except that a nuclear reactor is used as a heat source instead of a furnace burning fossil fuel. The installation and operating cost of nuclear plants in any given location and stage of technological development determine whether or not such plants are economically competitive with other types of thermal powerplants. They are becoming increasingly competitive. Efforts to reduce air pollution may advance the consideration of nuclear powerplants in some areas since these plants do not release hydrocarbons or other chemical substances which could contribute to air pollution problems. More elaborate and expensive air cleaning equipment than that now in use may be demanded of conventional plants. If required, the increased cost of air cleaning equipment would make nuclear plants relatively more attractive. On the other hand, disposal of radioactive and thermal wastes are potential problems which require solutions that do not endanger the environment.

Geothermal Energy

Use of the earth's natural heat, geothermal energy, in the form of steam and hot water for the generation of electric power, is receiving an increasing amount of attention. The Geysers area, north of San Francisco Bay, is a producing steam field and has been generating electric power since 1960. The Casa Diablo area in Mono County (South Lahontan Subregion) contains a potential steam field that may be as great as the Geysers area (1,000 MW). While neither of these areas may be a major source of power, there are other potential sites in the California Region where geothermal power developments may be undertaken.

Largest of the potential geothermal areas in the California Region is in the Colorado Desert Subregion southeast of Salton Sea. Exploration wells have been drilled to depth between 4,700 and 8,000 feet. Natural steam from these wells varies from 500° to 700°F and is associated with a brine of 30 percent salinity. Ultimate field potential is considered to be very large; however, present technical problems associated with the brine have prevented utilization of the geothermal steam. The opportunity to recover minerals from the brine and the potential water supply may eventually enhance the economics for electric power production.

Importation

It is anticipated that exchanges of hydroelectric power with the Pacific Northwest will continue until at least about 1990. After that time the Upper and Lower Colorado Regions may be the only near by source for importing power.

Advanced Technology

Exotic methods such as nuclear fusion, magnetohydrodynamics (MHD), fuel cells, thermionics, photovoltaics, and thermoelectrics fall in the category of advance technology. Of these, the most probable for use in the electric power system seems to be nuclear fusion or the MHD type of generator.

Nuclear fusion identifies a method of producing very large amounts of heat by uniting or fusing light nuclei as constrasted to production of heat by splitting or fissioning of heavy nuclei. Although a considerable research effort has been and is being exerted in an attempt to produce power by nuclear fusion, it has not yet been accomplished other than on a laboratory scale. Indications are that development of a power generator using a controlled nuclear fusion process is years away.

In a MHD generator, electric energy is produced by forcing a conducting fluid across a magnetic field with the generated current

taken off through two electrodes which are connected to an external load. Design of practicable, economically competitive generators of the MHD type will require considerable research.

Several of the other methods such as fuel cells, solar cells, and thermoelectric generators have been developed for special use but are currently not satisfactory for large-scale power production because of cost and size limitations.

Harnessing the power from tidal action has a significant potential in some parts of the world. The economic practicality of such a method is doubtful for the California Region because of unfavorable tidal limits and coastline configuration.

A large energy resource exists in the form of ordinary gravity waves (sea and swell) along the coast of the Region. At the present time, however, no economical means are available to convert the wave energy into useful power output. Should an economical method become available, that would be compatible with other shoreline uses, this source of power production could become a major supply.

Reduce Unit Use

The present use of electric power and energy in the Region is about one kilowatt and 5,300 KWH/yr. per person. It is estimated that by the year 2020 the average demand will by 7.7 KW and 46,000 KWH/yr. per person. This represents an increase in per capita rate of eight to nine times.

An alternative to satisfying the human need for power and those things it will accomplish (air conditioning, heating, manufacturing, etc.) is to forego the accomplishments. This alternative has a social well-being cost just like those that involve construction of electric powerplants. The cost in this case is measured in the reduced level of satisfaction or in the cost associated with being more efficient with available power supplies.

On the other hand, reducing per capita electric power use may have benefits such as maintaining a better quality of air and reducing thermal pollution.

PART V - PLANS AND ALTERNATIVES

Needs for goods and services were translated into requirements for resources taking into account the various means to satisfy needs and the availability and capability of the Region's resources. Plans and programs were then formulated to satisfy the established needs and requirements.

Development plans, herein presented as a project development plan, have been identified for each of the three sets of economic projections -- Base Plan, OBERS, and Series D-1970. The plan elements and estimated costs are based on using conventional water resources regulation methods and a continuation of present and ongoing programs. The plans are similar in their solutions of problems and their methods of resource development to satisfy projected needs and requirements. They differ only in scope of future development.

In the following text, planning objectives are discussed, followed by needs and requirements. Plan elements of a project development plan are presented together with their accomplishments and costs for each set of projections. Finally, alternative means of meeting requirements are examined as well as alternative assumptions regarding the impact of various levels of resource use.

RELATION TO PLANNING OBJECTIVES

An effort was made, in developing plans and alternatives, to explicitly consider the multiobjectives mentioned in the INTRODUCTION. It was found that different objectives are not achieved merely by developing different projections, nor is there necessarily a relationship between projections and objectives.

Meeting the needs derived from various projections does not assure that any specific multiobjective will be fully achieved. For example, if it could be demonstrated, for the National Economic Development objective, that the same level of agricultural

production could be obtained at the lower cost by shifting production from one region to another, it would improve national efficiency to do so. The gains (in efficiency) in one region would have to more than offset the losses in another region. Similarly, there may be numerous alternative programs or policies that would more nearly achieve Regional Development objectives than by satisfying the needs resulting from Base Plan projections.

Current planning must consider means to preserve or enhance environmental quality. An attempt to develop a separate plan to meet the Environmental Quality objective was unsuccessful because of the lack of needed information. The following tabulation outlines some of the required information and compares the data available for the Regional Development and Environmental Quality accounts for the California Region.

	REGIONAL DEVELOPMENT ACCOUNT		ENVIRONMENTAL QUALITY ACCOUNT	
REQUIREMENT FOR PLANNING	Examples of kind of data required	Is required data currently available	Examples of kind of data required	Is required data currently available
Needs for goods and services	Needs for food, recreation, electrical power, water quality	YES	Open space, ecological systems, water quality	NO
Means to satisfy needs	Crop production, recreation facilities, powerplants	SOME	Zoning, acquisitions, access, standards	NO
Resource capability	Amount of land and water, recreation sites, fuel supplies	YES	Amount of open space, ecological systems, miles of free flowing streams	NO
Alternative plans	Produce or import food, provide access to recreation sites or develop new sites, nuclear or thermal powerplants	SOME	Zone or acquire, develop or protect	NO
Cost	Cost of each alternative	SOME	Cost of each alternative	NO

Lacking specific information needed to develop an Environmental Quality plan, the approach used here is to examine alternatives for each of the projections that tend to preserve or enhance the environment and to recommend studies to provide the needed information in the PLAN OF ACTION portion of this appendix.

PROJECT DEVELOPMENT PLAN

The following section presents plans and programs, formulated to satisfy the needs identified by the three sets of projections -- Base Plan, OBERS, and Series D-1970. Development plans presented here should not be confused with the plan of action in the last section of this appendix. *The project development plan merely represents one approach to meeting requirements and establishes a base from which alternatives can be evaluated and tested.*

Considerably more data are available for the project development plan (particularly that designed to satisfy Base Plan projections) than for the alternatives. For example, individual water supply projects have been studied at the reconnaissance and feasibility levels and their costs estimated. This information is available for inclusion in the project development plan but only very limited data have been developed and are available for the alternatives that are discussed. Thus, the project development plan is presented in greater detail simply because more detail is available.

Needs and Requirements

Resource requirements and needed services are developed and presented in the various technical appendixes. They are summarized and shown in this report on Table 12 and represent a translation from the needs for goods and services previously discussed.

Needs for goods and services are relatively stable values because they relate to the final demand of the consumer. Resource requirements, however, are considerably more flexible since they

Table 12

NEEDS AND REQUIREMENTS
CALIFORNIA REGION

Function	Unit	1965	Base Plan 1980	Base Plan 2000	Base Plan 2020	OBERS 1980	OBERS 2000	OBERS 2020	Series D-1970 1980	Series D-1970 2000	Series D-1970 2020
Agriculture											
Irrigated cropland[a]	1,000 ac.	9,134	10,661	11,197	11,667	10,091	10,214	10,429	10,147	9,964	9,796
Non-irrigated cropland	1,000 ac.	1,607	1,087	731	502	1,087	731	502	1,087	731	502
Water supply	1,000 AF/yr.	29,780	34,750	37,020	38,860	29,811	30,297	31,599	33,025	33,188	32,846
Drainage	1,000 ac.	2,281	2,536	2,966	3,319	2,409	2,732	3,024	2,467	2,649	2,765
Municipal & Industrial											
Water supply	1,000 AF/yr.	4,142	6,209	9,994	15,132	6,233	9,800	14,346	5,896	8,659	11,648
Urban & industrial land	1,000 ac.	2,219	2,989	4,251	5,901	3,009	4,256	5,698	2,930	3,808	4,673
Recreation											
Recreation-days[b]	million/yr.	905	1,356	2,067	3,023	1,351	2,067	3,026	1,287	1,838	2,464
Water supply	1,000 AF/yr.	28	41	55	79	41	55	79	33	48	63
Water surface area	1,000 ac.	151	226	357	547	226	343	505	215	307	412
Land area	1,000 ac.	14,248	20,564	31,429	45,582	20,864	31,429	45,581	19,881	28,025	37,276
Fish and wildlife											
Angler-days	1,000/yr.	23,779	38,733	59,665	84,993	38,733	59,665	84,993	36,834	53,102	69,694
Hunter-days	1,000/yr.	9,843	14,979	21,191	27,085	14,979	21,191	27,085	14,230	18,815	22,210
Water supply	1,000 AF/yr.	702	1,125	1,344	1,587	1,125	1,344	1,587	1,175	1,344	1,587
Land	1,000 ac.	1,001	1,101	1,167	1,230	1,101	1,167	1,230	1,046	1,039	1,009
Land Management											
Mining water supply	1,000 AF/yr.	118	189	255	307	189	255	307	189	255	307
Land treatment											
Cropland	1,000 ac.	--	8,852	16,446	20,954	7,266	12,266	16,491			
Timber production	billion cu. ft. /yr.	1.05	1.53	2.37	3.40	1.53	2.37	3.40	1.45	2.11	2.78
Erosion & sediment damage reduction	million ac.	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Wildfire damage reduction	$ million/yr.	15.5	18.0	27.0	38.8	18.0	27.0	38.8	17.1	24.0	31.7
Flood Control											
Reduction of flood damages	$ million/yr.	107.4	171	324	659	166	306	563	164	283	505
Electric Power											
Energy	1,000 gwh/yr.	96	296	1,034	2,537	296	1,034	2,537	281	920	2,055
Peak power	1,000 mw	17	51	175	423	51	175	423	49	156	343
Water Quality											
M&I waste water	million population equivalents	31	43	60	82	43	60	82	41	54	66
Navigation											
Waterborne commerce	1,000 short tons/yr.	99,020	153,680	227,510	323,160	153,680	227,510	323,160	151,620	223,690	315,520
Shoreline Protection & Development											
Reduction of shoreline damage	$1,000/yr.	9,890	15,710	29,690	48,890	15,710	29,690	48,890	15,710	29,690	48,890

a/ Figures are for gross land area which excludes double cropped areas and includes associated non-cropped areas. See Appendix IV for details. Gross land area for Series D-1970 is not reported in Appendix IV. Estimates for Series D-1970 are obtained by using the same ratio of "Irrigated Acres" to "Gross Land Area" as the Base Plan.

b/ Includes recreational boating in navigable waters and shoreline recreation.

are derived from the demand for goods and services. For example, there are many mixes of land, water and other inputs combined with imports that could be employed to satisfy production needs. Furthermore, different assumptions regarding future technology, methods, and production yields have considerable influence on the magnitude of resource requirements.

Water Supply

Requirements for water supply are listed under five different functions but were combined for purposes of plan formulation. Total 2020 applied water requirements for out-of-stream use by agriculture, municipal and industrial, recreation, wildlife, and mining are 55,965,000 acre-feet for Base Plan, 47,918,000 acre-feet for OBERS, and 46,451,000 acre-feet for Series D-1970. These compare with the present (1965) applied water requirement of 34,770,000 acre-feet.

Since the foregoing figures represent application requirements it is necessary to add an estimated conveyance loss and deduct the potential for reuse of return flows in order to compute water development requirements. Such adjustments can only be considered approximate because of the many unknown factors that influence conveyance loss and reapplication of return flows.

Projected water development requirements are shown, together with the assured developed water supply, on Figure 6. Supplemental requirements for water in 2020 could be as low as 5 million acre-feet based on the Series D-1970 projection or as high as 13 million acre-feet using the Base Plan projection. Furthermore, the figure shows that these supplemental requirements will be strongly evident as early as 1980 or possibly as late as 1995. It should be pointed out that Figure 6 represents a regional summary and the location of the assured water supply does not necessarily correspond with location of water requirements.

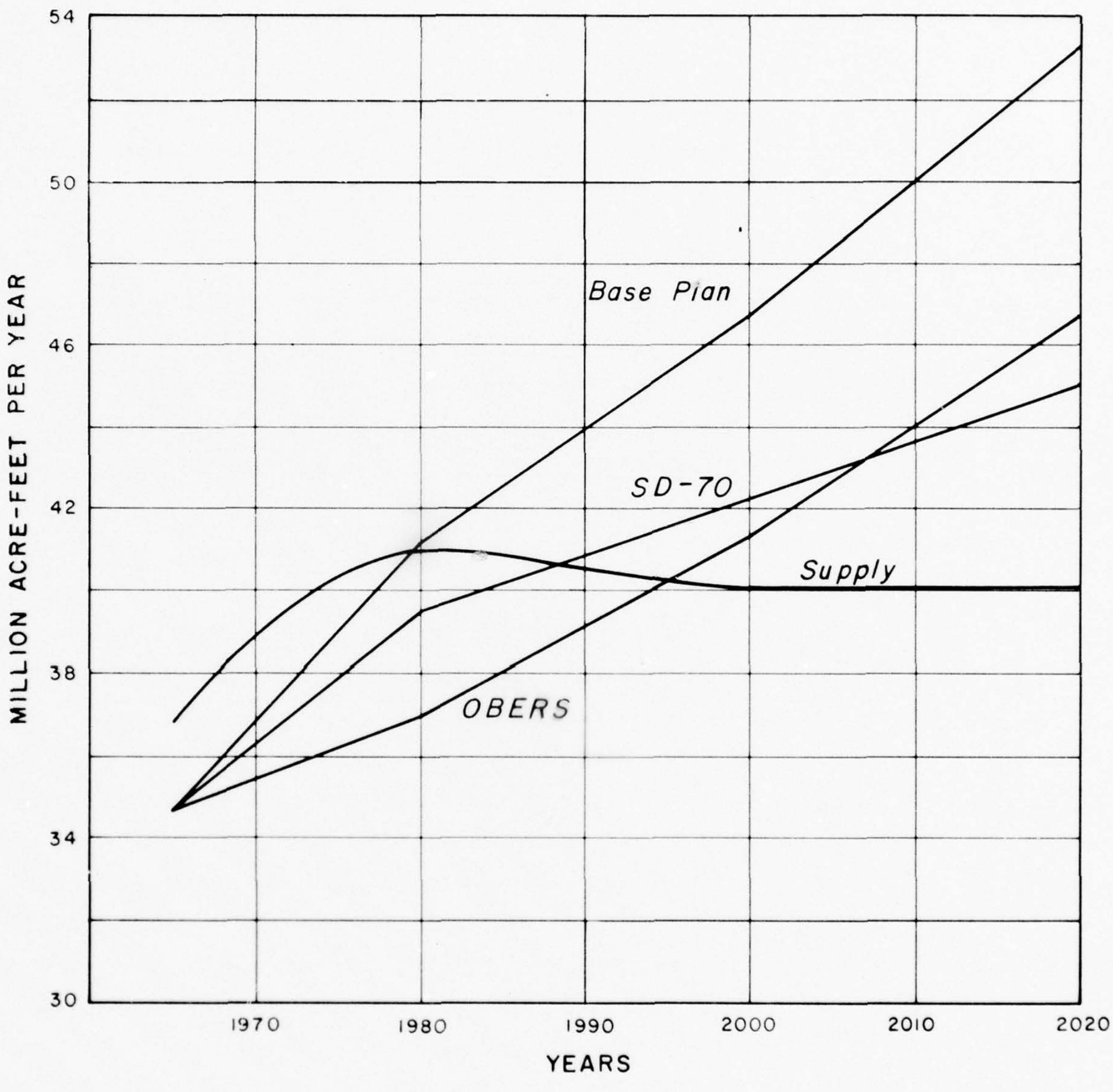

FIGURE 6
CALIFORNIA REGION
DEVELOPED WATER SUPPLY AND
WATER DEVELOPMENT REQUIREMENTS

This last point is further emphasized by referring to Map 4 which shows, by subregion, the distribution of natural water supplies in the California Region and areas of large water needs. Water deficits within any subregion can be met from local sources, transfers from other subregions, or possibly new types of development such as desalting.

No estimate of instream water requirement was developed in the framework study. Minimum streamflows for fisheries and water quality control are considered to be a significant factor and may be augmented by additional needs for aesthetics and free flowing rivers. Instream water requirements have, in the past, been a reaction to proposals for out-of-stream use and therefore comprehensive planning to satisfy both requirements has been difficult.

Related Land

Requirements for land resources in the California Region were developed by function and then compared with the available resources. Where available supplies of suitable land were limited, alternative means or other resources were substituted.

Requirements for gross agricultural cropland (irrigated and non-irrigated) are forecast to increase from 10,741,000 acres in 1965 to 12,169,000 acres for Base Plan, 10,931,000 acres for OBERS, or decline to 10,298,000 acres for Series D-1970. While these estimates for each projection appear to be close, it is the future growth that is significant. Increases in cropland under Base Plan projections will be 1,428,000 acres but using Series D-1970 projections there will be a decrease of 443,000 acres. (Non-irrigated cropland decreases for all projections are over one million acres.)

Projected changes in cropland are very sensitive to assumptions regarding crop yields. As covered previously in this appendix, crop yields are forecast to increase by 27 to 140 percent between 1965 and 2020. With the growth in yields much of the increased

need for food and fiber production will be satisfied by increases in crop yields rather than increased farm acreage.

Municipal and industrial land requirements show a marked increase. They are projected to grow from 2,219,000 acres presently to almost 6 million acres under Base Plan or to about 4.7 million acres using Series D-1970. Variations in urban densities account for different urban land requirements between Base Plan and OBERS projections of about 200 thousand acres.

Land requirements for fish and wildlife are about one million acres and are projected to increase by a modest amount. These are generally single purpose lands used for wildlife refuges. Requirements for recreation lands are both single purpose (parks, campground, etc.) and multiple-purpose natural environment. Total 2020 land requirements for recreation are almost one-half of the total region area and reflect the latent needs of a large population. Much of this requirement is for natural environment areas with low density use.

Resource Development

Satisfying resource requirements as itemized on Table 12 requires a comprehensive approach since there are overlapping and conflicting requirements for a limited quantity of resources. Where resource supplies are extremely limited or even non-existent, the expression of a requirement must be considered as theoretical or latent rather than an actual demand that must be satisfied. (There is no shoreline or navigation need satisfied within an inland region even though the population of that region might represent a latent demand on such resources if they were to become available.)

An alternative approach to developing limited resources to satisfy requirements is in resource planning and administration. This is the concept followed in utilizing our forest and rangeland resources. It can also be applied to shoreline and open space in

metropolitan areas. And, most important to this study, it could be applied to the surface water resources of the California Region.

Plan Elements

A project development plan was assembled to show how the needs and requirements might be satisfied using resources and services available in the Region. Most of the plan elements shown in Table 13 are of the conventional type, similar to projects and programs used to meet existing needs.

Future requirements for water supply can be met by surface water regulation within the Region. As shown in Table 5, in RESOURCE SUPPLY, most of the available water is in the North Coastal and Sacramento Basin Subregions. North Coastal supplies are necessary to satisfy Base Plan level requirements but would not be mandatory under OBERS or Series D-1970 projections. Waste water reclamation of 560,000 acre-feet per year is included as a plan element for the South Coastal Subregion.

Maps 5 through 15 depict the project development plan for Base Plan needs and requirements. Those features that would not be necessary to satisfy the lower projections have been circled on the maps, and those features that would be needed in a different time period or would be reduced in scope or size are marked with an asterisk. Again it should be emphasized that these maps show *one alternative method* for meeting possible future needs.

Regional power requirements for Base Plan and OBERS projections are identical. Although the distribution of the power requirements differ, it is assumed that power would be transmitted to the areas of need. Thermal electric generation will account for about 96 percent of the supplemental requirements. The remainder is supplied by importation (2 percent) and hydroelectric (2 percent). The 80,400 fewer megawatts required by the Series D-1970 projections are accounted for by a corresponding reduction in fossil fuel facilities.

Table 1[illegible]

ELEMENTS OF PROJECT DEVELOPMENT PLAN
CALIFORNIA REGION

Plan Element	Unit	Existing (1965)	BASE PLAN 1966-1980	BASE PLAN 1981-2000	BASE PLAN 2001-2020	OBERS 1966-1980	OBERS 1981-2000	OBERS 2001-2020	Series D-1970 1966-1980	Series D-1970 1981-2000	Series D-1970 2001-2020
Water Supply											
Storage dams	each	--	66	43	30	48	20	24	57	17	26
Reservoir storage	1,000 AF	--	28,840	27,580	23,410	26,556	16,237	13,959	27,221	4,140	10,525
Diversion dams	each	--	5	5	7	3	2	1	2	3	2
Waste water reclamation	1,000 AF/yr.	30	2	454	104	2	4	554	10	0	550
Pumping plants	1,000 hp.	--	4,500	900	1,400	4,144	287	628	4,245	756	1,174
Canals	miles	--	1,100	500	130	1,120	319	77	1,120	276	69
Pipelines	miles	--	700	200	110	689	128	75	751	82	51
Distribution system	1,000 ac.	--	1,562	710	656	927	207	311	1,000	53	-56
Project-type drainge	1,000 ac.	--	1,490	450	350	1,404	202	242	1,435	[illegible]	297
Electric Power											
Hydro powerplants	mw	5,330	4,686	2,900	0	4,686	2,900	0	4,686	2,900	0
Thermal powerplants	mw	15,258	29,200	140,000	301,000	29,200	140,000	301,000	27,000	[illegible]	241,000
Flood Control											
Flood control capacity	1,000 AF	5,915	4,564	5,458	1,995	4,564	4,691	2,075	4,564	4,691	2,075
Levees	bank miles	3,209	549	521	835	549	520	820	526	[illegible]	827
Channel improvements	miles	2,558	1,238	785	486	1,239	774	505	1,225	742	489
Regulation of flood plain use	stream miles	--	235	280	537	234	262	396	197	189	362
Watershed treatment	1,000 ac.	--	3,617	4,507	344	3,617	4,507	344	3,617	4,507	344
Recreation											
Development & facilities Land Classes I & II	1,000 ac.	1,182	251	92	119	238	91	122	250	92	119
Water surface	1,000 ac.	151	18	13	19	18	13	10	18	13	10
Recreation opportunity	million rec.-days	905	275	238	331	275	238	329	275	238	329
Fish and Wildlife											
Angling opportunity	1,000 days	--	2,873	5,200	6,439	2,873	5,200	6,439	On-going programs of Federal and State fish and wildlife agencies are expected to meet all angling demands. There will be an unmet need in waterfowl hunting.		
Hunting opportunity	1,000 days	--	3,222	4,063	3,664	3,222	4,063	3,664			
Commercial Navigation											
Channels											
Reworking existing ch.	miles	348	189	150	83	189	150	83	189	150	83
New channels	miles	--	24	34	12	24	34	12	24	34	12
Basins and anchorage Deepening existing	acres	1,266	1,148	1,612	505	1,148	1,612	505	1,148	1,612	505
New	acres	--	794	307	340	794	307	340	794	307	340
Breakwaters & jetties	miles	24	0.1	0.2	0.4	0.1	0.2	0.4	0.1	0.2	0.4
Commercial terminal berths	each	313	32	54	59	32	54	59	32	54	59
Cargo handling areas	acres	3,569	1,388	2,030	2,720	1,388	2,030	2,720	1,388	2,030	2,720
Recreational Navigation											
Boat berths	each	41,225	50,275	86,000	84,800	49,600	80,925	93,185	47,575	72,500	72,900
Boat launching facilities	lane	762	548	1,231	1,960	564	1,287	1,998	533	1,211	1,925
Transient boat moorings	each	7,900	8,750	12,950	21,400	9,000	12,300	19,100	8,350	10,850	19,500
Shoreline Protection & Development											
Shoreline stabilization	miles	--	21.5	23.5	9.0	21.5	23.5	9.0	21.5	23.5	9.0
Beach replenishment	miles	--	4.5	7.5	6.0	4.5	7.5	6.0	4.5	7.5	6.0
Seawall	miles	--	8.0	7.6	7.0	8.0	7.6	7.0	8.0	7.6	7.0
Development of new beach	miles	--	2.0	8.0	20.0	2.0	8.0	20.0	2.0	8.0	20.0
Scenic shoreline	miles	96	246	79	5	246	79	5	246	79	5
Swimming beaches	miles	107	8	21	23	8	21	23	8	21	23
Nonswimming beaches	miles	90	16	3	3	16	3	3	16	3	3
Land Treatment											
Irrigated land treatment On-farm water application & drainage improvement	1,000 ac.	--	3,121	2,764	1,499	2,566	1,881	1,223	2,887	2,418	1,243
Other cultural measures	1,000 ac.	--	2,692	2,184	1,499	2,175	1,621	1,223	2,491	1,911	1,243
Management measures	1,000 ac.	--	3,026	2,633	1,499	2,513	2,066	1,223	2,800	2,304	1,243
Non-irrigated cropland treatment	1,000 ac.	--	13	13	11	14	12	10	13	13	11
Grazing land treatment	1,000 ac.	--	4,050	5,219	124	4,050	5,219	124	4,050	5,219	124
Timberland treatment	1,000 ac.	--	1,005	1,651	73	1,005	1,651	73	1,005	1,651	73
Erosion & sediment treatment	1,000 ac.	--	2,980	3,869	344	2,980	3,855	323	2,980	3,869	344
Water Quality											
M&I waste water treatment	million population equivalents	17	33	60	82	33	60	82	31	54	66

Reduction of residual flood damages for all three projected levels of development is accomplished by a combination of structural and non-structural measures. These measures comprise dams and reservoirs, levees, channels, watershed treatment, regulation of flood-plain use, and flood forecasting and warning. For Base Plan projections, the development plan calls for an augmentation of 1965 flood control measures. OBERS and Series D-1970 projections require identical watershed treatment and flood forecasting programs and slight decreases in required quantities of flood control storage, levees, channel improvement, and regulation of flood plain use.

Recreation plans using OBERS projections call for programs involving development of 451,000 acres of land, 41,000 acres of water surface and for associated facilities to provide 842,000,000 days of recreation opportunity. Plans using Base Plan projections call for programs involving 462,000 acres of land, 50,000 acres of water surface and 844,000,000 recreation days of opportunity.

Because recreation demands are basically a function of population, Base Plan and OBERS future needs and corresponding plans are almost the same. Land programs include acquisition, participation by private landowners, opening of closed watersheds, zoning, and dual use of land and facilities. Facilities development includes boat launching ramps, picnic areas, marinas, hiking trails and others. Series D-1970 plan elements are similar to Base Plan and OBERS.

Satisfying recreation needs in the California Region is presented in two phases. The first is based on projection of present trends constrained within existing physical, legal, institutional and financial framework. Each Federal agency with the responsibility for providing recreation opportunities submitted projections of the future programs based on optimum possibilities for development of their resources. Non-Federal plans, including State, local

and private interests, were similarly projected based primarily on historical performance. In both cases, future plans were tempered by an awareness of existing constraints. Under this phase, only 37 percent of the total needs would be met, and these accomplishments are presented in Table 13. The second phase assumes that the legal, institutional and financial constraints are removed, and within this plan, as reported in the Recreation Appendix, all unmet recreation needs can be satisfied.

Under Base Plan projections fish and wildlife demands will exceed the supplies made available by the on-going program in all time frames. By year 2020 annual demands for angling opportunity will exceed the supply by 14.5 million days. The corresponding deficit in hunter days will be about 12.5 million which include some 1.6 million days of waterfowl hunting.

There is an additional demand for 45.8 million days of non-appropriative fish and wildlife use which it is assumed will be met.

The demands for fish and wildlife based on OBERS projections are the same as for Base Plan. Demands based on Series D-1970 projections are about 20 percent less than the other two projections.

A program to supplement on-going programs has been planned to meet all future fish and wildlife demands except for the 1.6 million days of waterfowl hunting. The estimated future accomplishments (shown in Table 13) of that supplemental program are expected to cost $81 million as shown in Table 14.

Based on the 1970 Series D projections a reduction in population would diminish projected demands for fishing and hunting, and thereby improve the success of the on-going programs and reduce the need for a supplemental program.

After implementation of fish and wildlife programs the only unmet needs will be for waterfowl hunting as shown in Table 16,

Unmet Needs. By 2020 these unmet needs will reach 1.56 million days for Base Plan and OBERS and 1.07 million for Series D-1970.

Plans to meet 2020 Base Plan projections for commercial navigation consist of new channels, improved or new basins and anchorages, and new breakwaters, terminals, and cargo handling areas. Recreational development in navigable waters consists of launching lanes, berths, and moorings for transient boats. OBERS projections require identical commercial navigation development and a slightly greater recreational navigation development because of the concentration of people in the South Coastal Subregion, an area particularly conducive to recreational boating in the ocean waters. The Series D-1970 plan is identical with the Base Plan for commercial navigation and includes a small reduction in scope of plan elements for recreational navigation.

Because the California Region's shoreline is a very limited resource and because its needs for development and production are virtually independent of the level of future growth, the three development plans are identical. The protection phase of these plans consists of additional structural measures and regulation of shoreline use. Shoreline recreational development consists of acquiring additional scenic shoreline and swimming and non-swimming beach.

Plan elements of the land treatment programs are designed to help meet food and fiber requirements by improving production with programs for irrigated and dry cropland, rangeland, and forest and woodland. Programs include, as appropriate, development of new lands, land management and treatment, and yield improvement. Land requirements are also provided for other such uses as urban, transportation, and mineral production.

Because the growth of red meat requirements is faster than the growth in productivity of the Region's rangeland, a shift from rangeland to alternative means of meeting the red meat requirements

will be needed. Without such a shift it would take almost three times as much rangeland as will be available in the Region in 2020. Important adjustments include shifts to large proportions of concentrates in livestock rations, importation of more feed grain and increased imports of livestock and livestock products from other regions. At the national level the OBERS projections indicate a balance between feed production and feed requirements by livestock. Thus, at least for the OBERS production levels, there will be no national feed shortages if each region produces its projected level of production.

Water quality requirements are closely related to the nature and quantity of water uses. The plan elements for the project development alternative include municipal and industrial waste water treatment, agricultural drainage treatment, collection of harbor waste effluent, water quality management programs in reservoirs, a water quality improvement project for the Salton Sea, correction of toxic mine drainage problems, and special studies of specific problem areas.

Costs

Functional costs of the plan elements contained in the project development plan are extracted from the various functional appendixes and are based upon available cost estimates from completed or underway studies or upon unit costs. Recreation costs are only those costs allocated to recreation for new water development projects to serve areas deficient in recreation water surface. Costs are shown in Table 14 and summarized in Table 15. This cost estimate is based upon a specific project development plan, and is the only estimate of cost available at this time for the California Region. Cost data are not available for each of the alternatives discussed in this report. For some alternatives (e.g. import high water using commodities) part of the cost would be transferred to other regions. Other alternatives (e.g. lower per capita use of M&I

water) would shift the cost to lost consumer satisfactions. Nevertheless, the costs in the tables can be considered as an estimate of the approximate magnitude of meeting the water related needs of the Region.

Based on the cost data in Table 14, the average annual water development cost (installation and OM&R) during the first time frame (1966-1980) amounts to $824 million to satisfy Base Plan projections, $735 million for the OBERS projections, and $750 million to meet Series D-1970 projections. Total estimated expenditures by Federal and non-federal agencies during the initial five years of the first time frame amount to about $1,095 million per year. This is well ahead of the average amount considered necessary by the results of this study. The heavy investment by the State of California in its State Water Project partly explains the magnitude of the current expenditure.

The estimated federal cost during the first time frame ranges from $387 million for Base Plan projections to $315 million to satisfy OBERS. Average annual expenditures during the initial five years have been only about $163 million, considerably less than the estimated amount the study results show to be necessary for the project development plans.

Accomplishments and Conflicts

The project development plan presented herein would meet a substantial portion of the needs and requirements previously described and enumerated in Table 12. The plan would essentially meet all needs for cropland, agricultural water supply and drainage, municipal and industrial water supply, electric power, M&I waste water treatment and commercial navigation. Partially satisfied needs include recreation, certain forms of fishing and hunting, forage production, timber production, and all forms of damage reduction, erosion and sediment, wildfire, and shoreline.

Table 14

COSTS OF PROJECT DEVELOPMENT PLANS
CALIFORNIA REGION

(millions of 1965 dollars)

Functions	Base Plan						OBERS						Series D-1970					
	1966-1980		1981-2000		2001-2020		1966-1980		1981-2000		2001-2020		1966-1980		1981-2000		2001-2020	
	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R	Install.	OM&R
Water Development Costs																		
Irrigation water supply and drainage	2,227	33.2	2,414	33.1	1,018	9.5	1,462	16.1	1,690	23.7	536	9.1	1,675	29.5	1,467	25.6	488	3.6
M&I water supply and treatment	2,767	96.4	1,716	54.2	2,951	76.0	2,615	75.4	1,497	45.6	1,857	60.7	2,645	71.8	754	34.0	892	36.4
Hydroelectric power	1,101	13.0	647	9.0	0	0	1,101	13.0	647	9.0	0	0	1,101	13.0	647	9.0	0	0
Navigation	500	13.1	906	21.0	936	25.3	502	13.1	930	21.5	1,051	26.1	499	14.5	846	23.1	882	27.8
Flood control	1,412	11.0	1,474	16.2	1,006	14.1	1,410	11.0	1,415	16.0	967	14.0	1,383	11.0	1,333	16.0	932	14.0
Shoreline protection and development	70	0.8	63	1.1	54	0.8	70	0.8	63	1.1	54	0.8	70	0.8	63	1.1	54	0.8
Recreation	142	4.2	75	1.5	100	3.0	85	4.2	40	1.5	68	3.0	133	4.2	80	1.5	61	3.0
Fish and wildlife	32	2.7	49	4.9	0	0	32	2.7	43	4.9	0	0	Not Available					
Water quality	2,350	43.3	3,221	59.4	3,065	65.8	2,316	42.4	3,088	53.8	2,793	54.1	2,280	34.3	2,916	46.8	2,582	43.5
Land management [a]	65	7.2	64	17.8	31	25.3	65	1.9	64	5.5	31	10.6	65	7.0	64	17.7	31	25.3
SUBTOTAL	10,666	224.9	10,629	218.2	9,161	219.8	9,658	180.6	9,483	182.6	7,357	178.4	9,851	186.1	8,175	174.8	5,942	154.4
Federal	(5,273)	(70.4)	(7,075)	(82.9)	(5,834)	(79.2)	(4,389)	(43.4)	(6,077)	(64.5)	(4,060)	(50.9)	(4,593)	(51.9)	(5,029)	(66.7)	(3,182)	(53.5)
Non-Federal	(5,393)	(154.5)	(3,554)	(135.3)	(3,327)	(140.6)	(5,269)	(137.2)	(3,406)	(118.1)	(3,297)	(127.5)	(5,258)	(134.2)	(3,146)	(108.1)	(2,760)	(100.9)
Associated Costs																		
Thermal electric power	3,373	410.0	14,189	1,969.0	31,523	4,164.0	3,373	410.0	14,189	1,969.0	31,523	4,164.0	3,200	NA	12,400	NA	25,200	NA
Transmission lines	2,766	73.1	10,360	273.1	20,800	423.0	2,766	73.1	10,360	273.1	20,800	423.0	NA					
Recreation	866	91.7	810	77.5	1,111	106.0	870	92.0	774	74.8	1,012	98.7	854	90.8	689	68.4	862	87.4
Land management	978	181.0	1,086	353.8	855	580.2	824	169.3	948	321.8	781	540.3	921	173.4	989	328.1	710	525.3
SUBTOTAL	7,983	755.8	26,445	2,673.4	54,289	5,273.2	7,833	744.4	26,271	2,638.7	54,116	5,226.0	4,975	264.2	14,078	396.5	26,772	612.7
TOTAL	18,649	980.7	37,074	2,891.6	63,450	5,493.0	17,491	925.0	35,754	2,821.3	61,473	5,404.4	14,826	450.3	22,253	571.3	32,714	767.1

a/ Includes water supply costs for mining.

Table 15

SUMMARY OF COSTS FOR PROJECT DEVELOPMENT PLANS
1966-2020 PROGRAM

(millions of dollars)

Functions	Base Plan Installation	Base Plan OM&R	OBERS Installation	OBERS OM&R	Series D-1970 Installation	Series D-1970 OM&R
Water Development Costs						
Irrigation water supply and drainage	5,659	75.8	3,688	48.9	3,630	58.7
M&I water supply and treatment	7,434	226.6	5,969	181.7	4,291	142.2
Hydroelectric power	1,748	22.0	1,748	22.0	1,748	22.0
Navigation	2,342	59.4	2,483	60.7	2,227	65.4
Flood control	3,892	41.3	3,792	41.0	3,653	41.0
Shoreline protection and development	187	2.7	187	2.7	187	2.7
Recreation	317	8.7	193	8.7	294	8.7
Fish and wildlife	81	7.6	81	7.6	NA	NA
Water quality	8,636	168.5	8,197	150.3	7,778	124.6
Land management a/	160	50.3	160	18.0	160	50.0
SUBTOTAL	30,456	662.9	26,498	541.6	23,968	515.3
Federal	18,182	232.5	14,526	158.8	12,804	172.1
Non-Federal	12,274	430.4	11,972	382.8	11,164	343.2
Associated Costs						
Thermal electric power	49,085	6,543.0	49,085	6,543.0	40,800	NA
Transmission lines	33,926	769.2	33,926	769.2	NA	NA
Recreation	2,787	275.2	2,656	265.5	2,405	246.6
Land management	2,919	1,115.0	2,553	1,031.4	2,620	1,026.8
SUBTOTAL	88,717	8,702.4	88,220	8,609.1	45,825	1,273.4
TOTAL	119,173	9,365.3	114,718	9,150.7	69,793	1,788.7

a/ Includes water supply costs for mining.

NA - Costs not available.

It must be borne in mind that although the project development plan fully or partially satisfies the appropriate human needs and requirements for water and related land resources, certain conflicts exist among the plan elements and requirements. For example, to satisfy the needs and requirements for Base Plan projections, most of the major stream systems of the North Coastal Subregion are shown as being developed for export water supply and flood control. Such development would conflict with their potential to provide certain fish, wildlife, and recreation opportunities. Another area of potential conflict exists in the use of the Region's shoreline. The shoreline, because it has the best access to cooling water, would be the logical location for most of the future thermal powerplants. However, it will require careful planning to prevent such development from seriously curtailing the recreational use of the shoreline, which will be in short supply in any case, and adversely affecting the shoreline's ecological balance due to the resulting thermal pollution.

Unmet Needs

As mentioned in the previous paragraphs, the project development plan does not meet certain needs and requirements in such areas as fish and wildlife, recreation, water quality and damage reduction. Unmet needs are summarized in Table 16 and discussed in the following paragraphs.

Recreation

Although an increased resource capacity of more than 840 million recreation days over the 1965 base will be provided, there will remain an unmet need (under Base Plan and OBERS) for facilities to accommodate an additional 1.5 billion recreation days of use by 2020. The need for an additional 563 thousand acres of land and 137 thousand acres of water surface would also remain unmet.

Table 16

UNMET NEEDS
CALIFORNIA REGION

Need	Unit	1965	Base Plan 1980	Base Plan 2000	Base Plan 2020	OBERS 1980	OBERS 2000	OBERS 2020	Series D-1970 1980	Series D-1970 2000	Series D-1970 2020
Recreation											
General	million rec.-days	432	518	918	1,474	519	923	1,483	463	710	961
Land (Cl. I & II)	1,000 ac.	147	197	356	563	211	374	597	177	284	399
Water surface	1,000 ac.	13	11	59	137	9	56	130	9	35	82
Boating in navigable waters											
Boat berths	1,000	10.32	6.29	8.45	10.50	4.79	7.89	17.24	5.31	5.83	6.70
Boat launching facilities	lanes	0	0	19	55	0	0	116	0	0	0
Transient boat moorings	each	1,350	0	0	0	0	400	5,600	0	0	0
Shoreline											
Swimming beaches	miles	0	0	0	5.0	0	9.0	44.0	0	0	5.0
Non-swimming beaches	miles	0.7	1.3	3.3	4.3	1.3	4.3	6.3	1.3	3.3	4.3
Food and Fiber											
Timber production	billion cu. ft./yr.	0	0.31	0.99	1.96	0.31	0.99	1.96	0.23	0.73	1.34
Fish and Wildlife											
Waterfowl hunter-days	million/yr.	0	0.50	1.10	1.56	0.50	1.10	1.56	0.43	0.87	1.07
Damage Reduction											
Erosion & sediment	million acres	7.2	4.2	0.3	0	4.2	0.3	0	4.2	0.3	0
Wildfire	$ million/yr.	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
Flood	$ million/yr.	107.4	104	101	118	100	93	95	101	94	97
Shoreline erosion	$ million/yr.	9.89	7.30	5.63	4.43	7.30	5.63	4.43	7.30	5.63	4.43
Water Quality											
M&I waste water treatment	million population equivalent	14.0	10.0	0	0	10.0	0	0	10.0	0	0

Because the shoreline of the California Region is a limited resource, not all needs and requirements associated with it can be met. By the year 2020, with completion of the structural and non-structural measures of the project development plan, there would be, in the South Coastal Subregion, a shortage of about 5 miles of swimming beach and 4 miles of non-swimming beach for Base Plan and Series D-1970 projections. OBERS projections show greater unmet needs for beaches because of a higher concentration of population in the coastal areas. All other shoreline recreation needs will be met.

The project development plan will not meet all needs and requirements for recreational boating in navigable waters. Shortages of future facilities for recreational navigation will occur in the Delta-Central Sierra, Sacramento Basin and San Joaquin Subregions where facilities for berthed boats and boat-launching ramps traditionally have been furnished by private investment.

Class IV (Unique Natural Areas) and Class V (Primitive Areas) are essentially fixed in supply and limited to specific geographic areas of the Region. Any unmet demands for recreation experiences on these exclusive lands are assumed to be satisfied by Class III areas. This is primarily a problem in the San Francisco Bay and South Coastal Subregions.

Fish and Wildlife

While the demand for waterfowl hunting will increase in the future, the supply cannot be maintained at current levels. The flyway population is dependent upon many variables outside the Region, even outside the United States. The available suitable waterfowl habitat, already limited, will be further depleted as other land requirements increase the demand for land reclamation and drainage projects. Beyond the planned and on-going programs there appears to be little opportunity to maintain waterfowl population. As a result, there would be, in 2020, an unmet demand of

about 1.6 million waterfowl hunter-days under Base Plan and OBERS projections and 1.1 million under Series D-1970.

Implementation of a scheme such as the project development plan to satisfy Base Plan projections would have serious effects on salmon, steelhead, and resident trout in the North Coastal Subregion and to a lesser degree would affect these resources in the Sacramento Basin and Delta-Central Sierra Subregions. Up to 25 percent of the angling use opportunities projected for the North Coastal Subregion would be lost. There would also be a significant reduction in commercial fisheries as well as big game habitat.

Timber Production

The forest lands of the Region have, even with the best management practices, the capability of producing a sustained yield of only 1.44 billion cubic feet per year by 2020. This is far less than the Base Plan and OBERS requirements of 3.4 billion cubic feet per year or the Series D-1970 projection of 2.78 billion. As a result, the California Region will have to import an increasing portion of its timber in the future.

Damage Reduction Needs

While it is theoretically possible to completely eliminate damages associated with water and related land resources, such a program would be neither practical nor economically justifiable.

For the categories of flood damage, erosion and sediment, wildfire and shoreline erosion, plans and programs were developed and damage reduced to a point where the additional damages prevented by increased protection were judged to be worth less than the cost of such increased protection.

Water Quality

Of the 1965 requirement for M&I waste water treatment (31 million population equivalent)[1/] only a little more than half (17 million) is receiving adequate treatment. The plan of development presented herein provides adequate funds to treat the remainder and also to treat the increased amounts resulting from population and economic growth. However, because of the large unmet need in 1965 and the magnitude of an adequate program, it is anticipated that treatment facilities will not catch up with the treatment requirement until the end of the second time frame, year 2000.

ALTERNATIVES

In a situation where there are few or no constraints on planning and where the means of satisfying one need does not preclude the satisfaction of another need, a single project development plan would be sufficient. The only test required would be that the plan is the most efficient in meeting needs. The actual situation in the California Region is one in which the various project plans to meet needs are often in conflict -- for example, surface development to meet water supply requirements may conflict with recreation, water quality, fish and wildlife, or environmental quality needs. In addition, uncertainities associated with economic projections, technological change, institutional and legal constraints, and social goals substantially reduce the reliability of the estimated effects of a single long-range plan.

Plan elements for meeting the needs for three sets of economic projections, based on specific assumptions related to resource requirements and various means, are presented in the previous

1/ Population equivalent is a term used to compare waste waters on a common base, normally considered to be 0.17 pounds BOD per day.

portion of this section. The following text discusses alternative plan elements for meeting the projected needs of each set of projections.

Water Supply

A dependable water supply is needed by the people of the Region for direct uses such as drinking and cooking and for indirect use in producing goods and services. Three general approaches are discussed herein to meet the water supply requirements or to produce the goods and services dependent upon a water supply. These are: first, an approach that relies on surface water development; second, an approach that utilizes other means for providing water supply; and, third, an approach that reduces water requirements.

The project development plan presented in the previous section relies on conventional methods of surface water development, augmented by a small amount of reclaimed waste water, to meet projected water development requirements for 2020. The water development requirements are based upon conventional use of water to produce goods and services taking into account future conditions of water use, increased crop yields, and other similar factors. A summary of this approach is shown in the following tabulation:

MEETING 1966-2020 WATER DEVELOPMENT
REQUIREMENTS BY CONVENTIONAL MEANS

(1,000 acre-feet per year)

	Base Plan	OBERS	Series D-1970
Authorized surface water development	1,100	1,100	1,100
Other surface development	11,200	4,700	3,000
Waste water reclamation	600	600	600
Total	12,900	6,400	4,700

As an alternative to conventional surface water development, it may be possible to develop part or all of the required water supply by other means such as:

Desalting	Weather Modification
Geothermal Development	Watershed Management
Waste Water Reclamation	Improved Project Management
Phreatophyte Control	Evaporation Reduction

The present status of these possible alternatives range from actually in limited use (desalting and waste water reclamation) to still experimental (weather modification and evaporation reduction).

Instead of developing a water supply to produce the needed goods and services, it may be possible to satisfy these same needs by reducing water requirements and at the same time increasing the well-being of the people. Some means that may accomplish this include:

Import Goods & Services	Reduce M&I Per Capita Use
Reduce Irrigation Requirements	
Increase Crop Yields	

The potential for reducing the rate of increase in the Region's water requirements may be substantial. However, considerably more attention needs to be given to investigations of the feasibility, limitations and costs of these alternatives. It could be argued, for example, that restrictions on fertilizers or pesticides will not permit projected crop yields to be attained; that the urban population may demand a life style that requires more water per person than projected; or, that the California Region has a competitive advantage over other regions in crop production and more crops should be produced here and exported. Within limits, each of these is a testable hypothesis and should be examined in subsequent studies.

The various alternative means of meeting water supply requirements are discussed in detail in PART IV, MEANS TO SATISFY. Some evaluation of these alternatives is presented in PART VI, EVALUATION,

and studies needed to determine the relevant relationships are outlined in PART VII, PLAN OF ACTION. When programs are finally implemented they will likely contain elements from each of the three approaches discussed above.

Electric Power

There is considerable controversy over the impact of power production on environmental quality. Everyone recognizes the benefits of electric power and the hardship resulting from interruption of electric service, even for short periods of time. Still, almost every proposal of another powerplant site brings a flood of objections. Projections show power requirements for the Region increasing 26 times between 1965 and 2020. Finding ways to meet the phenomenonal future power requirements with a minimal effect on environmental quality will be one of the great challenges of the decades ahead.

Considerable attention is being given to alternative ways to meet future power requirements. Current plans call for using fossil and nuclear fuels to satisfy most of the increasing power requirements. Hydroelectric production and power imports play lesser roles. The exact mix of ways to produce power will change over time as more information becomes available on the effect of changing technology and on the costs and impacts of the alternatives.

Like water, alternative plans for electric power should include the explicit consideration of alternative levels of use and production. Two areas need to be explored. First, how can technology reduce power requirements without losses in benefits from electric power. Projected technological advances are expected to more than double the value of output per unit of water input. However, projections for power show each dollar of output requiring twice as much power in 2020 as in 1965. Substitution of electric power for other inputs is desirable only if the total costs of power (including degradation

of the environment) becomes relatively cheaper than other inputs. While production costs may remain relatively low, serious environmental impacts are also likely.

Second, the potential for reducing electric power requirements through more efficient use must be examined. The Base Plan projections call for per capita power consumption to be about nine times as high in 2020 as in 1965. The impacts and costs of programs and policies that would reduce the startling growth of per capita requirements needs to be explored. For example, the costs and impacts of reducing future requirements by pricing policy, building codes (e.g. more insulation), taxes, subsidies, etc., should be examined. There would be an increase in the standard of living if the benefits from reducing power requirements (including improved environmental quality) are greater than the costs (including lost consumer satisfactions).

Still another alternative could be the development of environmental standards which must be met by power generating plants. With these standards available, the cost of meeting them can be determined and public and governmental agencies as well as the ultimate consumer can determine whether the convenience and usefulness of electric power to meet needs is worth the cost. Cost considerations would include economics, environmental quality (both improvements and detriments), and lost or gained consumer satisfaction.

Flood Control

Various means of reducing or eliminating flood damages are described in MEANS TO SATISFY NEEDS. The project development plan presented herein contains mixes of these alternative means that generally represent a "National Economic Development" objective. That is, based on judgement and preliminary estimates, projects and programs were selected and sized so that they would yield the greatest economic gain, in the form of flood damage reduction, at the least cost. The flood control portions of the project development

plan are not intended as firm elements for the various agencies to follow until the year 2020. Instead they are intended as guides in making future decisions regarding water resources development of the Region.

A specific aspect of the flood control plan is the mix of structural and non-structural measures in the solutions to flood problems. In the project development plan for Base Plan projections, about 86 percent of the cost of the flood control program involves structural solutions to flood control problems -- dams and reservoirs, levees, and channel improvements. The remaining 14 percent represents non-structural solutions such as watershed treatment, flood forecasting, and regulation of flood plain use. Flood control programs for OBERS and Series D-1970 projections have similarly relied principally upon structural solutions.

Several factors may influence the choice of methods for solution of flood problems or the amount of flood protection needed. These include:

- Changes in projected flood damages due to different growths in population and economic activities from those used in this report.
- Changes in other requirements that may influence the feasibility of a specific flood control measure. This would principally involve the need for water supply and the possibility of building multiple-purpose reservoirs with flood control as a function.
- Changes in sociological and environmental desires of the people. If it is the desire of the people to maintain a river as "free flowing" the protection that would be afforded by a dam and reservoir would not be available and alternative methods must be employed -- principally non-structural in nature.

For example, if for the purpose of maintaining the Smith, Klamath, Trinity, Eel and Van Duzen rivers as free flowing streams, no additional dams and reservoirs are permitted on these rivers beyond 1980, a different mix of flood control measures would be required in the North Coastal Subregion for the second and third time frames, 1980 to 2020. Such a mix would rely mainly on levees, channel improvements and non-structural measures. A comparison of the project development plan and a limited-structural solution (beyond 1980) for the North Coastal Subregion (Base Plan projections) is shown in Table 17.

Table 17

FLOOD CONTROL ALTERNATIVES
NORTH COASTAL SUBREGION

Item[a/]	1965	1980	2000	2020
Damages (1965 conditions)	10.7	13.7	22.6	40.3
Project Development Plan				
Incremental cost	--	51.3	108.7	112.6
Damage reduction	--	3.2	13.1	29.8
Residual damage	10.7	10.5	9.5	10.5
Limited-Structural Plan				
Incremental cost	--	51.3	61.2	88.9
Damage reduction	--	3.2	8.7	19.9
Residual damage	10.7	10.5	13.9	20.4

a/ Damages in $ million/yr; costs in $ million.

An examination of the table indicates that for the North Coastal Subregion a flood control program without new dams and reservoirs beyond 1980 is possible, but would not be as effective in reducing flood damages as the project development plan, which included major dams and reservoirs. In addition, the major costs of some non-structural measures are economic in nature, the determination of which are beyond the scope of this study. As a consequence, the actual costs of a limited-structural plan are greater than those shown. The choice of maintaining free

flowing streams versus providing maximum practical flood protection involves costs and benefits foregone in each case. While the costs of a flood control program and the benefits resulting therefrom are reasonably well definable, the benefits of a free flowing stream, or the benefits foregone by modifying it, are not easily definable at this time, at least not in an economic sense. These same factors hold true when comparing most water resource developments with environmental, ecological, and esthetic values and the choice of the proper balance is beyond the scope of this report. It will be for the people to choose, when the time requires, the proper balance between preservation and development or the optimum combination of both.

Other Functions

Alternatives are not discussed for the functions of recreation, fish and wildlife, land management, water quality, navigation, and shoreline protection and development because the plans are sufficiently general to encompass a range of alternatives or because no major conflicts in meeting projected needs are apparent at this time.

PART VI - EVALUATION

Planning for the management, use and development of water, land and related resources is an extremely complex process involving multiobjectives, multipurposes, alternative means, externalities, and a multitude of uncertainties. Many of the relationships discussed throughout this appendix relate to these elements of the planning process. This part of the appendix is an evaluation of some of the important factors that have not been evaluated elsewhere. The first section examines some of the assumptions and projections upon which the study is based. The next section evaluates the impact on environmental quality which would result from the plans and alternatives discussed in PART V. The final section looks at some of the other major problems and conflicts found in the study.

The purpose of the evaluation is to critically examine some of the study assumptions, problems and conflicts and their impact on water and land requirements. A better understanding of these problems, conflicts and assumptions provides the basis for developing the *plan of action* presented in PART VII of this report.

SENSITIVITY ANALYSIS

Sensitivity analysis involves examination of assumptions and projections to evaluate the effects on the planning objectives of changes in assumptions or levels of associated variables. The approach used here could also be labled "simulation." Simulation asks the question "what if?" In this case, what would be the effect on the requirement for water and related land resource development if different assumptions were chosen.

The following analysis is not a complete evaluation of the assumptions and projections but it does identify certain relationships that are important in water resource planning and provides the basis for recommendations for further study.

Factors Related to Water Requirements

M&I Water Use Rate

Average municipal and industrial water use in the California Region is currently 204 gallons per capita per day (gpcd) and is estimated to increase to about 246 gpcd by year 2020 under Base Plan projections or 233 gpcd under OBERS and Series D-1970 projections. This analysis in intended to show the total net effect of increasing the unit applied use of municipal and industrial water by 40 gpcd or 20 percent of present use. To make this analysis it is helpful to trace an example computation of M&I water from source of development to place of use and final disposition.

Using the projected 2020 population of about 55 million, the total annual delivery requirement would be 12,580,000 acre-feet per year with a unit use of 204 gpcd, and 15,040,000 acre-feet per year with a unit use of 244 gpcd or a difference of 2,460,000 acre-feet per year (about 20 percent).

There are several different assumptions which can be made regarding the differences between the two unit use rates. It is necessary to analyze these separately since the assumptions have considerable impact on net effect.

Assumption #1. The increase in unit use represents an "across-the-board" increase in all factors affecting unit use. Efficiency of use remains the same, relationship of indoor use to outdoor use (domestic) is the same, and the same portion of the total delivered water is consumptively used. In this case people just use more water in what might be described as a higher level of living with more water-using devices.

Assumption #2. The increase in unit use represents a decrease in efficiency which might result from water being easy to obtain and inexpensive.

Assumption #3. Similar to Assumption #1 except in this case add to the assumption that waste water reclamation will be practiced

to a higher degree. Reuse of return flow occurs primarily in the Central Valley where waste effluent from upstream areas is treated and returned to the stream for subsequent downstream use. Waste water reclamation is similar to recycling of water.

Depending on the assumption, a change in the per capita use from 204 to 244 gallons per day will require an increase in net water development requirements ranging from 1.5 to 2.0 million acre-feet by 2020. (See Table 18 for computation.) Thus, for every reduction of one gallon in the daily per capita use, the 2020 net development requirements are reduced by 40,000 to 50,000 acre-feet per year.

Irrigation Efficiency

Irrigation efficiency is defined as the relationship between "consumptive use of applied water" and "applied water". In computing irrigation requirements for the California Region, average field efficiency was found to vary from 60% to 70% under present conditions and is estimated to be about 70% in the future. For every 10 acre-feet delivered to the edge of the field, 7 acre-feet are used for crop production and 3 acre-feet runoff at the lower end of the field, evaporate, or percolate to ground water. Increasing irrigation efficiency is one method of reducing the need to develop more irrigation water supply. The purpose of this analysis is to show how much the need for future water supply development could be reduced if irrigation efficiency were increased.

To understand the factors involved, it is helpful to follow through an example computation starting with an assumed quantity of water development and ending with final outflow. Table 19, which shows the computation, is predicated on the general assumption that developed water supply is delivered to a service area where it undergoes an initial application to the cropped land. That portion of the applied water that is not consumptively used

Table 18

COMPUTATION OF M&I WATER USE
(1,000 AF/yr.)

Item	Assumption #1		Assumption #2		Assumption #3	
	204 gpcd	244 gpcd	204 gpcd	244 gpcd	204 gpcd	244 gpcd
Water development requirement	13,240	15,830	13,240	15,830	13,240	15,830
Conveyance loss to service area (5%)	660	790	660	790	660	790
Gross delivery to service area	12,580	15,040	12,580	15,040	12,580	15,040
Consumptive use of applied water (25%)	3,145	3,760	3,145	3,145[a/]	3,145	3,760
Return flow	9,435	11,280	9,435	11,895	9,435	11,280
Reuse of return flows (33%)	3,114	3,722	3,114	3,925	3,114	3,722
Consumptive loss of return flow (10%)	944	1,128	944	1,190	944	1,128
Reclamation of return flows (25%)	0	0	0	0	2,359	2,820
Outflow (assumed unavailable)	5,377	6,430	5,377	6,780	3,018	3,610
Effect of 20% higher unit use:						
Greater water development requirement	2,590		2,590		2,590	
More use of return flow	-608		-811		-608	
More reclamation of waste water	0		0		-461	
Net effect (additional requirement)	1,982		1,779		1,521	
Equivalent to:	32 gpcd		29 gpcd		25 gpcd	

a/ Consumptive use assumed to remain constant, reflecting lower efficiency.

Table 19

COMPUTATION OF IRRIGATION WATER USE
(Base Plan Requirements in 2020)
(1,000 AF/yr.)

Item	Field Efficiency 60%	70%	80%
Surface water supply development	36,800	33,730	31,550
Conveyance loss to service area (5%)	1,840	1,686	1,578
First Application			
Gross delivery to service area	34,960	32,044	29,972
Consumptive use of applied water	20,976	22,431	23,978
Return flow from 1st use	13,984	9,613	5,994
Consumptive loss of return flow (10%)	1,398	961	599
Outflow from service area (30%)	4,195	2,884	1,798
Second Application			
Reuse of return flow	8,391	5,768	3,597
Consumptive use of applied water	5,035	4,038	2,878
Return flow from 2nd use	3,356	1,730	719
Consumptive loss of return flow (10%)	336	173	72
Outflow from service area (30%)	1,007	519	216
Third Application			
Reuse of return flow	2,013	1,038	431
Consumptive use of applied water	1,208	727	345
Return flow from 3rd use	805	311	86
Consumptive loss of return flow (10%)	80	31	9
Outflow from service area (remainder)	725	280	77
Summary			
Water supply developed	36,800	33,730	31,550
Total applied water (3 applications)	45,364	38,850	34,000
Total consumptive use of applied water	27,219	27,196	27,201
Total consumptive losses	3,654	2,851	2,258
Total outflow from service area	5,927	3,683	2,091
Total service area efficiency	74%	81%	86%

Therefore, by increasing the field irrigation efficiency by 10% it reduces water supply development by	3,070	2,180
It also means that there is less outflow from the service area by . . . . . for whatever purposes it may serve.	2,240	1,592

by the plant or lost by evaporation from the adjacent soil is then available for reapplication if it can be captured and placed into another irrigation system. The same is assumed to take place one more time.

Obviously, reuse of return flow can be practiced more in some areas than others. In the Sacramento Basin it is possible to reuse return flows a number of times, or at least until it reaches the Delta, and even then it is used to repel saline water intrusion in the western Delta and Suisun Bay. In some areas of the San Joaquin Valley and Tulare Basin and in the Imperial Valley of the Colorado Desert irrigation return flows can be used only until they are rendered unfit for further use because of salt concentrations leached from the soil.

Table 19 is an example computation using three different field efficiencies to illustrate the effect of irrigation efficiency on water development requirements. As shown in the computation, "total consumptive use of applied water" is equal for all three efficiencies; (27,200,000 AF/yr. is approximately the agricultural consumptive use under Base Plan projection in 2020). However, less "water supply development" is required when higher efficiencies are attained.

The computation shows that increasing irrigation efficiency from 60 to 70 and from 70 to 80 percent will reduce Base Plan irrigation requirements by 3,070,000 AF/yr. and 2,180,000 AF/yr. respectively. (OBERS and Series D-1970 would be about 80% of these values.) However, only about 25% of the reduction in requirement will also show up as a reduction in stream depletion. In those systems that operate under low irrigation efficiencies the surplus return flows are higher and may produce secondary benefits to fish and wildlife by creating marsh areas, sloughs, and other water courses during the dry summer months.

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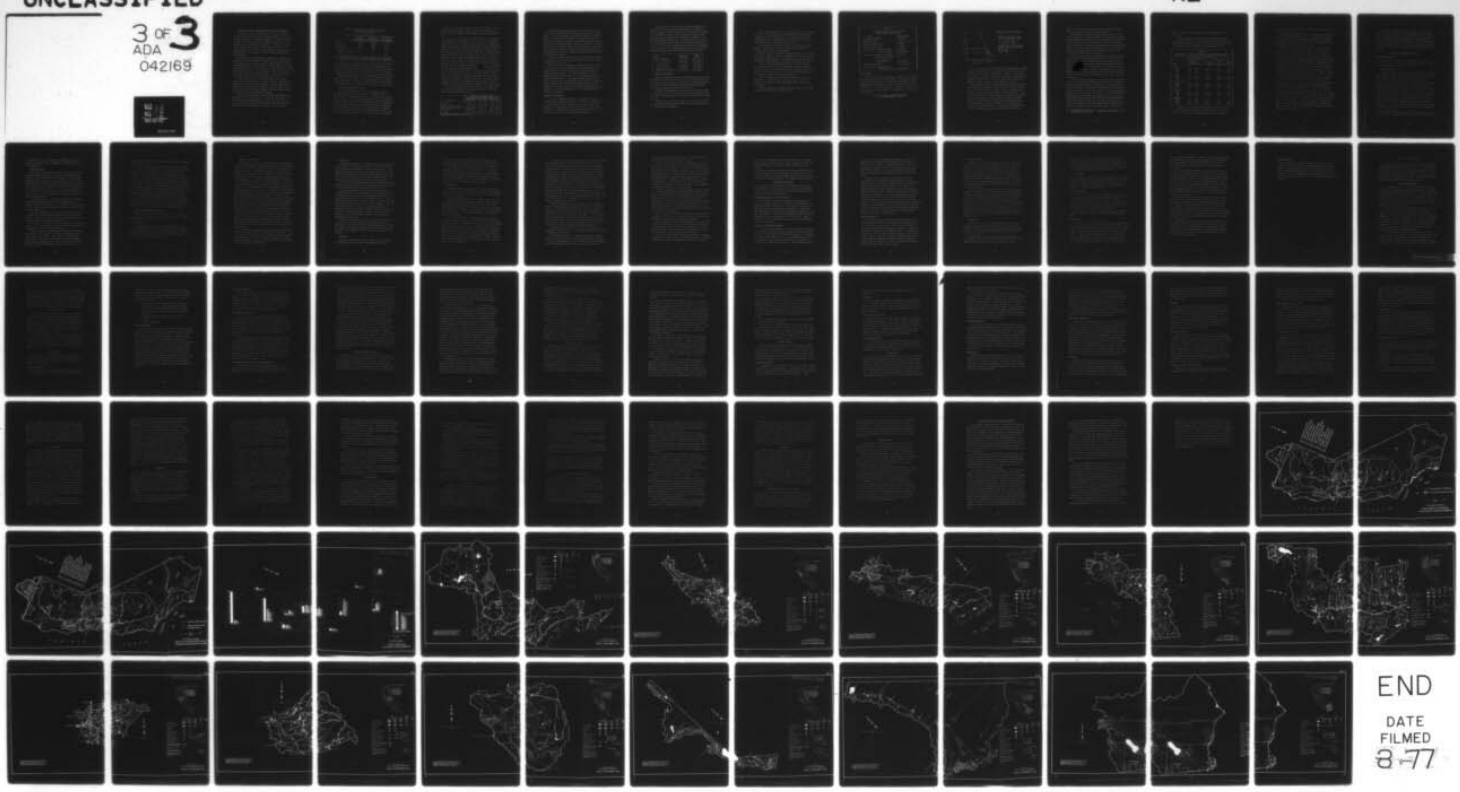

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Alternative Levels of Government Rice and Cotton Programs

Production levels of both rice and cotton are controlled through acreage allotment and price support programs. Forecasts as to what will happen to government programs are, at best, hazardous. The Base Plan (largest projection) indicates an increase of rice production from 16 million cwt in 1965 to 44 million cwt in 2020. Cotton increases are from 845 million pounds in 1965 to 1,992 million pounds in 2020. Other sources, however, indicate that the projected levels of production of these crops may substantially exceed demands.

As most of the rice produced in California is exported, export potential is a critical element in determining the future demand for California rice. Recently, dramatic yield increases in rice in some foreign countries have produced the "green revolution". There is growing evidence that major importers of California rice may soon become self-sufficient in rice production. When the Vietnam conflict ends, the large exports of California rice to that country will likely lessen and may eventually drop to near zero.

Cotton demand also seems to be declining. The continued development and declining price of synthetic fibers has resulted in large shifts toward the use of synthetics. Cotton experts are now forecasting no increase in the production level of cotton in the United States in the foreseeable future. The 1970 farm bill calls for a large cut in cotton acreage allotments.

What would be the economic and development consequences if the production of rice and cotton were to remain at the 1965 levels? The following tabulation shows the difference from Base Plan projections in gross output, water requirements, and employment for 2020 assuming constant production levels for rice and cotton.

Impact of Constant Rice and Cotton Production
at the 1965 Level Relative to
Base Plan Projection

	Decrease in Output (million dollars)	Decrease in Applied Water (1,000 AF/yr)	Decrease in Employment (1,000 employees)
Rice	138	2,486	.4
Cotton	372	2,018	2.5
Other Sectors	205	122	3.8
Subtotal	715	4,626	6.7
Percent of Regional Total a/	.07	8.3	.03

a/ Percent of gross output from input-output model, total water requirements, and total civilian employment from Appendix IV.

Obviously, if the market for rice and cotton is more like the 1965 level than the projected 2020 level, the reduction in water requirements will be substantial, but changes in output and employment will be relatively minor. In addition to the above effects, irrigated land requirements would drop by almost one million acres.

Reduction under OBERS and Series D-1970 projections would be smaller than presented above since projected increases in rice and cotton were smaller. For Series D-1970 projections, the reduction in new acreage in rice and cotton would be about 3/4 million acres.

Alternative Economic Structures

For any given population projection an infinite number of structures of the economy are possible. In addition, there is a wide range of potential population levels. The Base Plan and OBERS projections are for the same regional population but with different mixes of economic activity and subregional population distribution. The Series D-1970 projection is an alternative level of population with a mix similar to the Base Plan. Elsewhere in this appendix the effect of changes in the economic mix has been discussed relative to reductions in rice and cotton production and to importation

of livestock feed or meat products. This portion discusses alternative mixes in a general way to show the relative importance of various sectors in terms of water supply, gross output and employment.

Economists point out that the relevant measure for evaluating alternative levels of resource use is the value of the marginal product (VMP), i.e., the value of an additional unit of production. Economic optimization is achieved at the point where the additional value (VMP) is just equal to the additional cost (marginal cost). This is theoretically true for all resource uses. The grain farmer generally continues to use additional units of water as long as the additional value of output is greater than the additional cost -- so does the cotton farmer, the vegetable processor, the steel mill operator, and the home owner. Because marginal analysis requires that functional relationships between val[illegible] cost be established for each resource use and because such an [illegible]sis is very costly and time consuming, average rather than marginal relationships are shown in the following tabulation. No economic optimum condition can be specified based on average relationships alone. However, these data are available and given these data and a general understanding of the nature of the marginal relationships, positive statements about the relationships of alternate mixes can be made.

The following tabulation shows the percents of output, water requirements and employment for five major sectors for 1965 and under the 2020 Base Plan projections.

Sector	Percent of Regional Totals					
	Gross Output		Water Use[a]		Employment	
	1965	2020	1965	2020	1965	2020
Livestock	1.1	.3	.2	.4	.8	.1
Crops	2.5	.6	92.1	79.6	3.9	1.7
Agricultural Processing	8.5	2.0	1.4	1.8	3.1	1.4
Manufacturing & Mining	28.4	28.6	2.7	11.5	24.2	25.6
Services	59.5	68.5	3.6	6.7	68.0	71.2
Total	100	100	100	100	100	100

a/ Does not include households.

The preceding tabulation shows that the sectors that use most of the water (crops) provide relatively little output or employment. If alternative programs were being considered to stimulate growth in economic activity (output or employment), expansion of agriculture, through development of irrigation, would be relatively ineffective in promoting growth. While it is true that in the past, when most of the economic activity was tied directly to agriculture, economic growth was closely related to the economic condition of the farm sector. This is no longer true, and by 2020 the relationship will be even weaker.

To increase regional employment one percent through expansion of irrigation in 2020 would require nearly a 60 percent increase in the amount of irrigation.

Obviously, water development for irrigation does not appear to be an effective tool to encourage general economic growth in the California Region, although it may have significant impacts on localized rural economies. The same relationships that exist between the broad sectors listed in the preceding tabulation also exist within each sector. For example, among irrigated crops, certain crops are much more efficient users of water for producing income and employment. Hay and feed grains provide much less employment and income per acre-foot of water used than do fruit and vegetables. Additional information on these relationships are included in Appendix IV.

Population Distribution

It has been suggested that some of our problems could be solved through a better distribution of the Region's population or its municipal and industrial growth. Fewer people in the South Coastal area would result in less air pollution -- in the South Coastal area. Fewer people in the South Coastal area would result in less water demand -- for the South Coastal area.

Perhaps the best comparison that can be made regarding the effect of modifying population distribution is to examine the difference between projected needs and requirements under the Base Plan and OBERS projections. These projections assume the same total Regional population (54,941,000 people in 2020) but with different regional distributions. Population distribution is not the only difference between these two projections and therefore care must be exercised in comparing items which concern production of food and fiber. The following tabulation shows the population distribution under Base Plan and OBERS projections for 2020.

Item	Base Plan	OBERS
Region population	54,941,000	54,941,000
San Francisco Bay	11,255,000	9,869,000
South Coastal	23,771,000	31,914,000
Central Valley	12,038,000	7,582,000
Remainder of Region	7,877,000	5,576,000

Summary of Difference

Since the principal difference in population between Base Plan and OBERS is that fewer people are located in southern California under the Base Plan projection, the effects of shifting population from south to north (OBERS to Base Plan) are described in the following paragraphs and summarized in Table 20.

M&I water requirements would increase from 14.3 million acre-feet for OBERS to 15.1 million for Base Plan, reflecting the shift of southern California population to areas with a higher per capita water use.

There would be a very small change (0.1 percent) in the need for recreation opportunity reflecting the shift in population out of the South Coastal Subregion.

With a greater proportion of the population in the north there would be a slight increase in per capita demand for fishing and hunting due to the reduced difficulties facing people of large metropolitan areas to participate. The overall effect is slight and no modification was made in regional needs.

There would be no change in regional electric power demands. However, the population location shift would be followed by a similar location shift in power demands.

Regional needs for waste water treatment are the same for both projections. However, because of economies in scale resulting from the population concentration of the OBERS projection there would be an increase in the treatment cost under the Base Plan projection.

While total regional waterborne commerce remains the same, there would be a slight shift of population-related commodities. There would also be a shift in recreational navigation needs resulting in a \$153 million lower cost to satisfy the Base Plan projection of fewer berthing and launching facilities.

Effect on regional requirements for shoreline recreation is significant. Less population in the South Coastal area would decrease the demand for beaches and thereby reduce the otherwise unmet needs.

Projected annual flood damages (other than agriculture) would increase from \$482 million to \$572 million.

Table 20

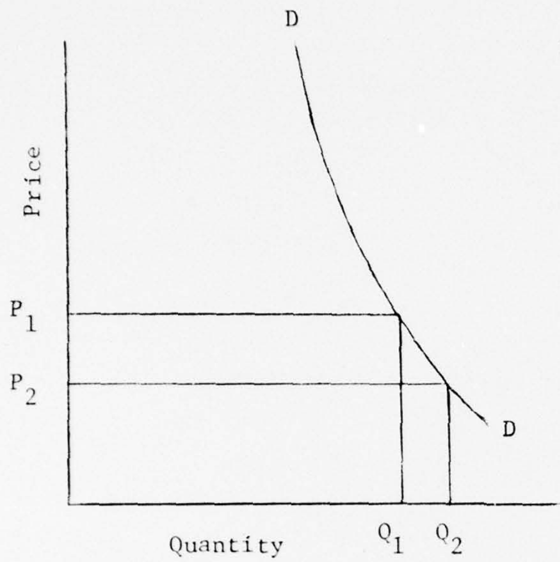
REGIONAL EFFECT OF POPULATION SHIFT
(From OBERS to Base Plan)

Item	Change in 2020
M&I water requirement	+ 786,000 AF
Recreation needs	- 3,000,000 rec-days
Fish and wildlife needs	no change
Electric power needs	no change
Water quality - treatment needs	no change
- cost of treatment	+ $394,000,000
Navigation - commercial shipping	no change
- recreation facilities	less
- cost of recreation facilities	- $153,000,000
Shoreline recreation	less unmet needs
Flood control - need for annual damage reduction	+ $90,000,000

Price Impacts

Economists label the relationship of market price to quantity purchased as "price elasticity of demand." If one percent change in the quantity purchased of a particular commodity has a large (greater than one percent) effect on its price, demand is said to be inelastic. If the effect on price is small (less than one percent) demand is labeled elastic. The coefficient of elasticity is calculated as:

$$E = \frac{\text{percent change in quantity demanded}}{\text{percent change in price}}$$



EXAMPLE OF INELASTIC DEMAND

Demand is inelastic if and when the percentage change in price $\left(\frac{P_1 - P_2}{P_1}\right)$ is greater than the percentage change in quantity demanded $\left(\frac{Q_2 - Q_1}{Q_1}\right)$

The price elasticity of most agricultural commodities is highly inelastic. Relatively small changes in the quantity purchased are associated with relatively large changes in prices. When there is an increase in the quantity produced of commodities with inelastic demand, prices must fall to clear the market, gross income of the producer decreases, and net income decreases even faster.

The inelastic demand for farm products, coupled with the fact that production of individual farmers has little effect on prices while the collective impact is great, has been a significant contribution to the chronic farm problem of low income and low rates of return to capital and labor. Administrative efforts to improve the price-demand-income relationship have resulted in numerous marketing arrangements and extensive acreage control and price support programs. In 1968, for example, the Commodity Credit Corporation paid producers over $3 billion in price support and diversion payments, and 58 million acres were diverted from

production of feed grain, wheat or cotton, or diverted under conservation reserve or cropland adjustment programs.[1/]

The magnitude of the price support program, and the controversy it generates, is often overlooked in water resource planning. An important impact of large scale water development is its effect on farm commodity prices. When production levels are increased more than demand, farm prices, gross income, and net income decline. Because these changes affect all producers -- not just the new producers -- income distribution is also affected. Usually, the resulting redistribution is less equitable.

What are the price impacts associated with the Base Plan projected level of production as compared with the OBERS projection? Both the Base Plan and the OBERS projections were based on the specific assumption that national supply and demand would remain in balance with constant relative prices. Crop production levels for Base Plan were based on regional interpretations of projected trends and are supported by trends in acreage increases which are expected to be forthcoming from projects already funded or under construction.

From the regional viewpoint, the projected increase in production may achieve regional development objectives if the increase comes from relative decreases in production in other regions. In order to evaluate the potential for increasing the market share produced in California, it would be necessary to know the comparative advantage of California with other regions. On a nationwide basis, OBERS projections assume that trends in shifts in market shares among regions would continue until 1980 but regional shares would not change thereafter. Base Plan projections assume that the share of the market in California would continue to grow for some crops and decrease for others, but unlike OBERS, no analysis is

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1/ U.S. Department of Agriculture, Agriculture Statistics, 1969, Washington, D.C., p. 541

made to indicate the specific level of production on other regions.

Table 21 illustrates the effect that increased production would theoretically have on product prices assuming that the higher agricultural production is not offset by decreased production elsewhere and results in an addition to total national supply.

Table 21

SENSITIVITY OF PRICES TO CHANGES IN CROP PRODUCTION LEVELS
(Example based on assuming difference in Base Plan and OBERS production adds to the total supply.)

Crop	Percent of U.S. Production OBERS	Percent of U.S. Production Base Plan	Difference (Percent)	Assumed Price Elasticity	Price Change (Percent)
Rice					
1980	27.0	34.3	+ 7.3	-0.5	- 14.6
2000	27.0	41.7	+ 14.7	-0.5	- 29.4
2020	27.0	41.1	+ 14.1	-0.5	- 28.2
Citrus					
1980	17.5	25.5	+ 8.8	-0.67	- 13.1
2000	17.5	26.6	+ 9.1	-0.67	- 13.6
2020	17.5	27.7	+ 10.2	-0.67	- 15.2
Noncitrus fruit					
1980	47.9	60.0	+ 12.1	-0.7	- 17.3
2000	47.9	63.0	+ 15.1	-0.7	- 21.6
2020	47.9	66.0	+ 18.1	-0.7	- 25.9
Tree nuts					
1980	56.4	68.3	+ 11.9	-1.0	- 11.9
2000	56.4	67.7	+ 11.3	-1.0	- 11.3
2020	56.4	67.3	+ 10.9	-1.0	- 10.9
Vegetables					
1980	34.3	39.0	+ 4.7	-0.5	- 9.4
2000	34.3	45.0	+ 10.7	-0.5	- 21.4
2020	34.3	47.0	+ 12.7	-0.5	- 25.4

Using rice as an example, the difference between OBERS and Base Plan projections in 1980 is 7.3 percent of the national production. The 7.3 percent increase in national rice production

would with a -0.5 price elasticity, result in a 14.6 percent drop in the price of rice.

It should be emphasized that price elasticities for the categories in the foregoing table were not estimated for this study. The assumed elasticities were obtained by reviewing estimates of price elasticities for a variety of individual crops and selecting the estimates which seemed most appropriate.

Because of the complex nature of the price relationships, estimating price elasticities for groups of commodities (e.g., vegetables, or noncitrus fruits) is difficult. For example, an individual crop may have different elasticities in the foreign market and in the domestic market as well as different elasticities for the fresh, processed, and frozen markets. In addition, elasticities vary from the farm level to the retail level. However, regardless of the complexities, any program that affects the level of production of farm commodities by several percent of the total national market must include price effects in its analysis in order to avoid the possibility of overlooking serious secondary costs.

The change in price for some of the crops listed in Table 21 is so large that other adjustments would be forthcoming before prices fell as far as is indicated. However, the changes indicated by declining price and income should receive additional study.

If the increased production were limited to only a few crops the impact would be less serious because farmers could shift to other crops as increased production caused price declines. However, for the Base Plan most of the California's major crops are projected at higher levels than OBERS. In addition, the prospect for the two major crops of the Region that are controlled by government programs -- rice and cotton -- points toward little potential for increased demand. (See the discussion of the outlook for rice and cotton earlier in this section.)

In summary, data requirements for evaluation of price impacts must include price elasticities and comparative advantage among regions. Rough estimates of price elasticities and the assumptions used herein indicate that the difference between OBERS and Base Plan projections of agricultural production could have major impacts on prices and income. Data are not available that would indicate the extent of these impacts upon the California Region or upon other regions.

EFFECTS ON ENVIRONMENTAL QUALITY

Project Development Plan

Implementation of the project development plan would cause environmental impacts upon several of the Region's natural resources. The following paragraphs discuss these impacts.

Wild and Scenic Rivers

Reservoir development of surface water would be needed to meet water supply and flood control requirements of Base Plan projections. These reservoirs would reduce the potential of 13 major streams to attain the wild category of the Wild and Scenic River System. Reservoirs do not necessarily preclude the attainment of the remaining two categories of scenic and recreation rivers. The surface water development sites are located on 13 major streams which have a total of 1,200 stream miles. Many miles of these streams could be classified, by reaches, in the wild, scenic, or recreation classification. Portions of five of the Region's six rivers have been included for study under Section 5(d) of the Wild and Scenic Rivers Act (P.L. 90-542) would be changed in some manner by reservoir development. Some of this change would involve increased enjoyment and appreciation of these rivers which has been denied previously because of lack of access.

Flood control works would require 1,905 bank miles of levees and 2,510 miles of stream channel work. These works are not located

in wilderness areas but are usually near communities and other built-up areas where they are designed to be compatible with the local environment.

Fish and Wildlife

Surface water development as portrayed in the project development plan would affect almost 1,950 miles of anadromous fishery streams if used to satisfy Base Plan projections. These streams represent the best anadromous fishery habitat areas of the Region. The overall effect on the fishery would be mixed, with some stream reaches blocked to fish migration while other reaches would benefit from controlled releases of water. It has been estimated that up to one-quarter of the fishery resources of the North Coastal area could be lost as a result of water development proposed under the project development plan.

The relative effects of surface development would be reduced with corresponding reductions in projected requirements. For example, any detrimental effects to the anadromous fishery would be relatively small if the plan designed to meet Series D-1970 projections were implemented.

Many surface developments in the Sacramento River Basin could be formulated to provide improved streamflow through controlled releases. Such releases would be essential to improvement of the anadromous fishery by expanding spawning areas.

The effect of the project development plan upon the commercial fishery has not been evaluated. Commercial fisheries are discussed in Appendix IV, Economic Base and Projections.

The bays, estuaries, and fresh water streams are vital links in the life cycle of a number of species of ocean-going marine life that are taken commercially. These areas provide spawning and nursery care for the young of such species as salmon, steelhead, striped bass, and American shad. Some of man's activities involving water resource developments have affected some species by

disrupting the essential link between the ocean and bays, estuaries, and fresh water streams.

Some progress has been made toward solving problems caused to the species by blocking and drying up of spawning areas, diversion of eggs and fry, and dumping of wastes into streams, bays and estuaries. More constructive efforts are required to save the aquatic environment and maintain both inland and offshore harvests.

Proposed developments would affect a large part of the wildlife resources of the North Coastal Subregion. Almost all elements of the project development plan would eliminate some kind of wildlife habitat, with deer habitat being particularly vulnerable. The better upland game habitat, located in the canyon bottoms would be inundated or destroyed by associated construction activities.

Winter ranges and some summer ranges of almost every major North Coast deer herd would be affected by projected water developments. Winter ranges are usually located along the larger canyon bottoms, and along with associated riparian habitat would be lost as these areas are usually the most desirable reservoir sites.

Unique Natural and Cultural Sites

Although increased development may cause loss of desirable unique natural or cultural sites, it would be necessary to identify specific project locations to determine such impacts.

Wilderness Areas

Wilderness area would not be significantly affected by water project developments unless conveyance systems were constructed across such areas. Conflicts with wilderness areas may result from future transportation systems, utility rights-of-way, and from possible degradation through recreation use.

Estuaries and Wetlands

Implementation of the project development plans would have an impact in varying degrees on waterfowl habitat areas. Streamflow diversion works, involving export of water from river basins, could result in changes in the ecological systems of estuarine areas. However, it is believed that the net result of flow diversions may not materially alter estuaries in a detrimental way. There is a lack of knowledge of consequences concerning quantifiable measures in ecologic and economic terms. Of prime importance is the impact on the San Francisco Bay, Sacramento-San Joaquin Delta, and Eel River Delta. The Peripheral Canal would be operated to distribute a fresh water supply to all parts of the interior of the Sacramento-San Joaquin Delta and at the same time provide a positive downstream flow of water through the Delta channels to San Francisco Bay. These flows would protect the Delta fisheries, primarily the striped bass and salmon by restoring normal flow direction and by counter-acting pollution of the San Joaquin River. Urbanization, power-plant siting, and industrial plant location may cause conflicts along the shore of San Francisco Bay, Humboldt Bay, Monterey Bay (includes Elkhorn Slough), and Morro Bay. Development to meet urban, power, recreation boating, and industrial needs threaten the existence of wildlife habitat at Lake Earl and Talawa Lake, Del Norte County; Bolinas Lagoon, Marin County; Mugu Lagoon, Ventura County; Sunset Bay, Anaheim Bay, Bolsa Bay, and Upper Newport Bay, Orange County; and San Elijo Lagoon and Tijuana River Estuary, San Diego County.

The grasslands area along the trough of the San Joaquin River provides a tremendous resource for waterfowl and shorebirds. Loss of this habitat through conversion of acreage to intensive agricultural production or other uses would mean a reduction in numbers and possibly species. Soils in this area may be too poor in quality to allow conversion to cropland uses.

Shorelines

The Region's shoreline is a valuable resource, the utilization of which needs to be planned in a manner to best serve the people with a minimum of detrimental effect upon the environment. Water regulating measures could change the natural supply of sand to the coast and thus influence the littoral beach transport and nourishment. Developments such as beach parks and wildlife refuges would help preserve the environmental qualities of the shoreline.

Some form of land use planning must be implemented and enforced. Besides the estuaries, lagoon areas, and marshes which need protection we must define those areas that have aesthetic value.

According to Appendix XIV, Electric Power, there may be a requirement for 40 or more powerplant sites along the coast to meet the demand for electric power. Nuclear powerplant siting limits other development uses up to 2-1/2 miles from the site. Each site would therefore require five miles of coast or a total of 200 miles. The 200 miles might include reaches of scenic headlands, sea cliffs, rocky shorelines and other vistas. Studies should be made to determine the effects of nuclear powerplant construction and operation upon coastline environment. Results of these studies would provide the basis for developing corrective measures aimed at minimizing adverse effects.

Powerplant sites could produce positive effects through allocation of open space or recreational use compatible with nuclear development. Development for power where great quantities of water are necessary for cooling purposes, should be studied to determine the effects of discharge of cooling water on the stability of the ecology.

Open Space

Whether the developments necessary under the lower economic activity projections would reduce the environmental quality of

open space depends in a large measure on the adequacy of the approaches used in planning and construction. This is true for urban development, powerplant siting, or flood control works.

Urban expansion under Base Plan projections will require an additional 3.7 million acres by the year 2020. If inadequate zoning allows prime agricultural land to go into housing tracts, or if political expedience permit urban communities in a flood plain, then we can expect open space and the supply of prime agricultural land to suffer from the growth projected.

Alternative Plans

Anadromous fisheries should not be to seriously affected by most alternative plans for developing water supply (alternatives to surface water regulation), although the impact of weather modification is presently unknown.

Wilderness areas may be affected by weather modification, but the impact cannot be evaluated without further studies. It would seem that the wilderness areas would play a major role in any planning scheme involving weather modification, because the wilderness lands would act as water storage areas. If the weather modification scheme involved modifying or changing the landscape, then conflicts may develop.

The environmental impact on habitat areas by development of alternative sources of water may be critical in specific locations. For example, removal of phreatophytes along the Lower Colorado River would reduce habitat for one species of dove so severely that its future would be uncertain. Prior to implementation of any phreatophyte control programs, studies should be undertaken to determine the effect on fish and wildlife. Waste water reclamation should provide a positive effect on the environment, as long as consideration is given to the environment in the disposal of salts and other residue from such treatments.

If increasing crop yields require additional use of fertilizers and pesticides, residues should not be allowed to enter systems where they could eventually reach and harm wildlife and degrade wildlife habitat. Harmful residues should be prevented from reaching river systems where they could seriously affect estuarine and ocean resources. Reducing M&I per capita use of water, improving existing project operations, reducing crop irrigation requirement, and increasing irrigation efficiency generally should provide a positive impact on the Region's environment since total water requirements would be reduced. In local situations adverse effects may evolve, but we must assume that these methods of improving the water supply picture also would include improvement of water quality. Open space and the supply of agricultural land may suffer from improved water uses. Also, the grassland-wetland areas of the San Joaquin Valley could be damaged since this area exists now because of agricultural return water.

Ground-water development does not appear to have a significant impact on the environment, although high water tables resulting from lack of pumping could cause drainage problems. Overdraft of ground water has created subsidence which is more damaging to developed land than to environmental conditions. If a ground-water basin is hydraulically connected to surface water there may be a loss of ponded water or marshland habitat through excessive ground-water removal. Studies should be undertaken to determine such effects in areas that have significant wildlife habitat.

Water quality improvement is a necessity for environmental enhancement. Habitat, aesthetics, recreation; all would be enhanced by improving water quality.

Alternatives that result in reducing flow through estuarine areas may create an imbalance between fresh water flows and tidal action, thus changing the ecological systems within these estuarines. Also of importance to estuarine areas is the quality of water

entering the estuary from river systems. Changes in salinity may change the character of cover in marsh areas.

Desalinization of ocean water as an alternative source of water might involve impacts on the environment and ecological systems in several areas. First, the placement of desalting plants could compete with other land uses such as scenic areas, fish and wildlife habitat areas, recreation areas, urban development needs, and industrial needs. Second, there could be an effect on the environment from the disposal of waste products from the process of desalinization. Other conflicts that could be significant include power transmission lines to the plant site and conveyance and distribution systems for exporting water.

Open space considerations would not change materially regardless of alternatives chosen for developing water supply. Population projections and regional distribution within any population projection would appear to be the most critical variables in analyzing open space impacts. Without proper planning for urban development, flood control works, water development and so forth, effective open space will not be available. Retention of open space through retention of woodlands and grazing lands within urban influence zones is imperative.

Under the project development and alternative plans there are many beneficial effects to the environment from erosion and sedimentation control and reduced damages from wildfires.

The improved water quality, increased water availability and lengthened streamflow into the dry season affect many segments of the environment. Stream fisheries are improved with the better quality water and the increased water yield benefits recreation, fish and wildlife, agriculture and M&I water supplies.

Decreased sediment loads in streams greatly enhance spawning opportunities for fish, improve the recreation qualities of streams, and decrease detrimental sedimentation downstream. An adverse

effect of the decreased sediment load in streams is its negative impact on beach nutrition. However, man's inability to contol all sedimentation insures a continuing source of material for the beaches.

Most of the benefits of reduced wildfires are fairly obvious. Wildlife habitat, protective watershed cover, timber resources, recreation qualities, and scenic beauty are but a few of the natural resources which are spared damage from wildfires under these plans.

PROBLEMS AND CONFLICTS

Conflicts exist among objectives and between various means (plan elements) to satisfy demands. The following discusses some of the conflicts among multiobjectives and evaluates plan elements as they influence different objectives.

Environmental Quality vs Other Objectives

The objectives of national and regional development and, in part, the well-being objective are attained by the production of goods and services. Achievement of these objectives, however, has many times resulted in environmental degradation. Everyone has been made aware of the problems of overcrowding and pollution of the land, air and water. They have been generally discussed along with other problems in the preceding part of this section. Special attention is given to environmental quality in the PLAN OF ACTION portion of this report.

Regional vs National Development

As part of the United States, people in the California Region have a major interest in national development. However, they have an even more vital interest in regional development. If the Region can improve its position, even if it is at the expense of the rest of the nation, it may consider itself better off. Witness the competition for major federal contracts. From the regional point

of view, it is generally considered desirable to increase the Region's share of production and output over time. However, increases in air pollution, crowding, and crime rates are some of the reasons causing many people to question the desirability of rapid economic growth. While almost all planning groups still strive for growth, there is increasing interest in controlled growth.

Assuming that an increased level of production under a regional objective is acheived through reduction of production elsewhere, there would still be conflicts between regional objectives and national well-being objectives. For example, the Federal Government has had a program for many decades designed to improve farm incomes, and, in 1969 paid farmers over $3 billion in various support payments. The shifting of significant quantities of production from other regions to California would result in increased program costs to maintain the same level of net farm incomes. If net farm income is maintained, the government programs would have to be expanded in both the case where prices fall due to excess production and where prices are constant and production shifts to California. Regional objectives could be achieved in the latter case, but not in the former.

Dams and Reservoirs

An important element of water resource development is the multiple-purpose reservoir. A reservoir may be operated to provide water supply, flood control, electric power, recreational opportunities, improve water quality, and preserve or enhance fish and wildlife resources. By combining a number of functions into one project, as with a multiple-purpose reservoir, all functions benefit from the joint use of facilities and functional costs are thereby reduced. However, more emphasis should be applied on locating dams and reservoirs to avoid interference with wildlife habitat or damage to other resource values.

Fish and Wildlife

Construction of a dam and reservoir can have both adverse and beneficial effects upon fish and wildlife resources. A dam will create an obstacle preventing anadromous fish from reaching upstream spawning beds and, even if methods are employed to permit spawning fish to overcome the dam (fish ladders, trapping and trucking), the reservoir inundates many miles of spawning and rearing habitat as well as inundating the stream habitat of resident fish. Attempts to mitigate these losses by construction of hatcheries and artificial spawning areas have been expensive and have met with mixed success.

A reservoir also can inundate lands valuable to big game, upland game, and waterfowl. The valley floors, foothills, and riparian lands are generally the most productive and the most important to game birds and animals. For example, the size and health of a deer herd is usually determined by the carrying capacity of the winter range and the best winter range is often in the valley areas that are potential reservoir sites. On the other hand, reservoirs have enhanced fishery resources by creating freshwater lakes. Controlled releases from storage in these reservoirs may be used to augment downstream flows for fish during the normally dry summer and fall seasons.

Recreation

Reservoirs constitute an important element in the overall recreation program of the California Region. For example, Folsom Reservoir on the American River provided 2,405,000 recreation-days of use in 1969 consisting of swimming, boating, camping, picnicking, and other uses.

Some recreational use is associated with, and dependent upon free-flowing rivers. These uses include whitewater boating, river rafting, and enjoyment of a river in its natural setting.

Construction of a dam and reservoir can either conflict with or improve these latter uses. Water released from storage can provide year-round flows in reaches downstream of these structures, and streams that were naturally intermittent can be improved thereby increasing the associated recreation activities.

Shorelines

The principal source of beach-building material is the natural process of weathering (erosion) and stream transport in drainage basins tributary to the ocean. Dams and reservoirs can have an adverse effect upon the shoreline region by reducing sediment contribution by streams in the littoral zone.

Levees and Channels

The solution of a particular flood problem by construction of levees and/or the improvement of the hydraulic characteristics of a stream channel can conflict with the desire to preserve the riparian area in its native state for aesthetic and recreational purposes. Attempts are being made to design and construct levees and channels that are compatible with these values.

Care should be exercised in channel maintenance methods that utilize herbicides or pesticides which might damage the aquatic biota.

Water Quality

The importance of water in every day life is usually accepted without any thought of where it comes from and how it became pure. However, in man's handling of water the quality is usually changed, and this change almost always results in a lowering of the water quality. Before water quality problems can be recognized and measured, standards must be established for specific uses. When these standards are violated, problems become apparent. Future water quality conditions resulting from projected population and

economic growth are difficult to predict, but the California Region is sufficiently populated and industrialized so that future water quality problems are expected to be similar to existing ones. Increasing volumes of waste material will require treatment and safe disposal.

Most of the Region's population will be located in the San Francisco Bay area and South Coastal Subregions. Man's activities can upset the delicate balance of water quality in coastal waters, bays and estuaries. The effect can be significant because of man's preference for living in and developing areas adjacent to these waters. The effects of municipal and industrial waste discharge upon San Francisco Bay and Los Angeles harbor are growing concerns. One encouraging example of water quality control is the improvement of San Diego Bay by eliminating or reducing major waste discharges into its waters.

Boats and ships have caused problems to man's health and to aquatic life by discharging wastes and petroleum products, trash, and garbage into waters of the Region. Water development plans must recognize the possibility of adverse effects on estuaries where reduction of streamflow allows sea-water intrusion. Also increases in irrigation and other related activities could increase waste loads on estuaries. Irrigated agriculture can be anticipated to produce greater salinity, pesticide, and nutrient loads on surface and ground waters.

Thermal-electric powerplants are projected for the future which would dissipate large quantities of waste heat. Care must be taken to prevent thermal alteration of the Region's streams, lakes, reservoirs and estuaries and to prevent harmful alteration of the biological communities of each making their waters unfit for other beneficial purposes.

Mineral Resources

The extraction of commercial minerals must be done with consideration for the environment, before, during and following the process. Recognition must be given to possible effects of mining upon the soil, water and vegetal cover. Production sites should be restored to prevent landscape scars and drainage of toxic wastes into soils and waters which could cause irreversible damage to the ecosystem.

PART VII - PLAN OF ACTION

A framework plan for the California Region should set forth a program that, if implemented, would result in the future development and best use of our water and related land resources in such a manner that they would satisfy all foreseeable short- and long-term needs. The principal goals involved here are "best use of resources" and "satisfying future needs." Comprehensive planning requires that these goals be considered together.

BEST USE OF RESOURCES

In the planning process, a future need, requirement, or problem is usually identified and alternative methods of satisfying the need or solving the problem are formulated. These alternative methods may involve the use of natural resources such as water and land, or they may require expenditure of capital and labor. Use or expenditure of resources can be an irreversable process and once committed to a future use, other opportunities for resource development may be foregone forever.

Resource planning might be described as planning for the best use, or combination of uses, of our water and related land resources. For each resource segment (such as a river basin) all potential uses should be considered. These uses must be evaluated with regard to the future requirements for each specific resource or for similar resources. Furthermore, the planner must have an awareness of the total availability of each resource since this type of planning becomes more crucial as available resources become limited relative to demands for them.

The concept of resource planning can be applied to water resources such as those of the North Coastal Subregion even though they now appear to be abundant. Requirements for new water supplies to meet irrigation, municipal and industrial growth and needs for flood protection are in conflict with esthetic demands

for free-flowing and scenic rivers as well as fish and wildlife needs, particularly the anadromous fishery. The resource planning approach, applied to the North Coast, could bring together a complete picture of the North Coast resources and measure them against the potential requirements for these resources. At the same time, alternative means of satisfying requirements would be assessed in order to evaluate the relative need for North Coastal resources.

SATISFYING NEEDS

The approach followed for many water resource investigations in the California Region has been to estimate future needs in specific areas, translate these needs into requirements for water and land resources, and then formulate a resource development or project development plan that would satisfy the projected requirements. Depending upon the scope of study, related needs and requirements of adjoining areas, adjacent river basins, or other subregions are taken into consideration.

In the planning process associated with this approach, alternative solutions and methods of satisfying the resource requirements are identified and evaluated for suitability and efficiency in accomplishing the established goals. Multiple-purpose programs and projects usually produce the most efficient and satisfactory results.

PLANNING GOALS

The plan of action in this report is based on an approach that strives to reduce uncertainties, maintain flexibility, utilize alternative approaches, employ sequential decision-making and recognize multiobjectives.

Reduce Uncertainties

Problems and situations caused by uncertainties and lack of information are discussed in various portions throughout this

report, but especially in the sections relating to sensitivity analysis and alternative plans. The plan of action should therefore attempt to improve decision-making by reducing uncertainties to the maximum extent practicable. Explicit means to reduce uncertainties include:

a. Studies to improve the reliability and confidence of existing data and to provide missing data. Priority is given to plan elements which show the best potential for satisfying needs considering all the various objectives.

b. The testing and use of models, both physical and economic.

c. Prototype evaluation.

Maintain Flexibility

While much can be done to improve the reliability of the data required for long-range planning, uncertainties will always remain, especially for the more distant projections. In order to avoid costly errors that might result from these uncertainties, flexibility in adopted plans should be maintained. Flexibility is achieved by including more than one alternative means (plan element) for satisfying needs. If conditions develop that make any plan element unsatisfactory, needs could be met by alternative means. This is particularly important for those needs that might be met by multipurpose programs or projects. For example, alternative methods of providing flood control should be identified other than by reserving capacity in multipurpose reservoirs in case water supply requirements are met by alternative means and the water supply function is vital to the justification of the multipurpose reservoir.

Alternative Approaches

The two approaches previously discussed, planning for best use of resources and planning to satisfy needs, are examples of alternative planning approaches. In the section entitled MEANS TO SATISFY NEEDS there is a discussion on alternative methods involving development and nondevelopment of resources. These are also alternative approaches. In fact, most of that section of the report might be described as alternative approaches.

Sequential Decision-Making

A plan of action is above all necessary for making timely decisions and providing the information needed for assuring that later decisions can be made when required. No decisions are made before they are necessary or concerning the exact nature or scope of plan elements in the distant future. The planning process produces information upon which decisions are made. Results of each sequential decision gives direction to the ensuing planning activities.

The sequential decision-making approach is essential because of the number of alternatives and the uncertainty (number of possible outcomes) associated with the supply (alternatives) and demand (requirements) of water and related resources. For example, in the simple case where there are only four alternatives each with three possible outcomes, there are a total of 81 possible future conditions, each of which might require different decision. Each future decision depends on which of the many conditions are relevant at the time a decision is made.

Environmental Quality and Well-being Objectives

Water and related land resources must be developed in such a way that it would not result in significant degradation to the environment or a decrease in well-being of the people. The public

is expressing a growing preference for environmental protection or enhancement even at the expense of expanding production. This preference is being evidenced by abandoning plans, halting construction, or deferring projects until more definite studies have been made to establish the effects on the environment. Our commitment to future generations must shift from simply providing more goods and services to providing for the total well-being of the people, including a quality environment. Because environmental quality and well-being needs have not been fully identified at this time, the action plan must include a program to overcome this deficiency.

Water and related land development to meet production needs does not appear to be urgent at this time. Because there are alternative means of satisfying increased needs the consequences of failure to meet certain projected production requirements in the Region are relatively insignificant. This is particularly true for several crops that use large quantities of water and land, but does not necessarily apply to our environmental quality or esthetic needs which are still largely undefined. The decision to implement major resource development programs is delayed as long as possible so that maximum advantage may be taken of the results of studies currently underway and other information that may become available. The objectives of all future reconnaissance and feasibility studies should be to provide specific answers at specific points in time.

CRITICAL DECISION TIME POINTS

The warning has often been issued that it requires about 20 years to plan, design, and construct major water projects. Design and construction are generally specific phases that take place after a decision has been made to implement the results of the planning process. A period of five to ten years, depending upon size of project, will usually accommodate this task. Where a major

storage reservoir is involved, several years may be required following construction to initially fill the reservoir to an operating level. In the California Region, storage to runoff ratios have rarely exceeded unity and filling is usually no problem. In future projects, particularly with offstream storage, filling criteria may be more critical.

A series of *critical decision time points* can usually be associated with any problem or need. The first time for decision occurs when a forthcoming problem or need is recognized and steps are taken to initiate an investigation of the potential problem. (The terms "problem" and "need" are usually interchageable since a problem implies the need for a solution.) Results from the investigation will lead into the second decision, that is, what should be done about the potential problem. The second decision may be responsible for initiating a study of possible solutions. This would be followed by several other decisions that would narrow the field of possible solutions down to the most feasible and most acceptable. Through the formulation and evaluation process, solution plans would evolve and could be feedback into the decision process. It is usually at this point that actions are proposed and decisions are made regarding the manner of implementation. Even the decision not to proceed with a program or a project is a possible course of action. It is not uncommon to spend 15 years or so involved in this planning activity - at least that was the experience of the Central Valley Project and the State Water Project in California.

Examination of Table 12, "Needs and Requirements" together with an appraisal of the Region's present status should produce an awareness of where the critical problems exist and when action regarding future problems might be required. Requirements for water supply are currently being satisfied and the outlook for the immediate future (first time frame) is favorable. Most needs are

being met and while damage from floods and erosion continue, studies and programs are underway that would reduce damages to an acceptable level. Only our needs for water quality control appear to be inadequately met.

Requirements for waste water treatment in 1965 were for a population equivalent of 31 million. However, the treatment level at that time was only equivalent to 17 million resulting in a present unmet need of 14 million. Obviously, the California Region is incurring a degradation of its environmental quality equal to this unmet need. Undoubtedly a portion of this degradation is being diluted by the Region's water resources to a generally acceptable level, while the other portion is causing pollution problems in receiving waters such as San Francisco Bay.

Average annual damages from uncontrolled floods is estimated to be $107 million. Means to control a portion of these floodflows have been formulated and evaluated and found to be in the best interest of the Region and the nation and have therefore been proposed for implementation. Continuing programs by Federal, State, and local agencies are regularly authorized and funded to maintain wildfire and erosion damage within reasonable limits.

ENVIRONMENTAL QUALITY

The lack of quantitative information on environmental relationships is a major obstacle in developing national programs and policies on environmental quality. As a first step for closing this gap, a major effort should be made to develop a comprehensive environmental resource inventory. Just as an economic base is required for an analysis of economic activity, the establishment of an environmental quality base is a prerequisite to sound environmental planning. Inventories are needed of open and green spaces, wild and scenic rivers, lakes, beaches, archeological and historical resources, water, land, and air quality and other components of

environmental quality. Emphasis should be on the relationship of the Region's resources in meeting human needs for environmental quality.

The next step toward an environmental plan is establishing levels of people's needs for environmental quality. To some extent these needs, like educational needs for example, will have to be determined through the democratic process. Nevertheless, ascertaining people's desires for environmental quality must be made a part of the planning process. These also must be qualitative determinations obtained from interested public groups and responsible policy makers after displaying to them alternative ways of meeting needs of the Region, together with the costs thereof, and the benefits or detriments of each with respect to environmental quality. There is much that can be done to identify preferences of people for environmental quality. Programs and studies to estimate these needs should be increased.

Not enough is known about the alternative means for preserving and enhancing environmental quality. Efforts are being made to evaluate the environmental impacts of programs to meet other objectives, e.g., regional development, but more attention needs to be given to programs to meet environmental quality objectives.

In addition to complying with the Federal and State legislation on environmental quality, each agency should evaluate their programs to determine how changes could be made to protect or enhance the environment.

Programs or projects that would have significant negative impacts on environmental quality should not be recommended or approved for implementation until the executive and legislative branches of government, representing the public, have been fully informed of the negative environmental impacts and the alternative ways of meeting the needs of the people. If alternative means are not available to meet production requirements without significant

degradation of the environment, the public representatives should be so informed and alternative ways of meeting needs with lower levels of production should be explored.

The concept of a national land use policy should be supported and all agencies concerned with land use should work toward implementing a comprehensive land use plan. A national land use policy is being considered by the Congress which would place the basic responsibility for land use planning with the individual states.

Full support should be given to the principle that the cost of pollution prevention should be included in the price of the product.

Recycling programs and programs to bring open space and parks to urban areas should be supported.

Finally, we must recognize that preservation and enhancement of our environment is a national objective and that no other objective has a greater inherent claim to our natural resources. Quality water, air and surroundings can no longer be considered free goods that can be traded at no cost for more output. Our aim should be to meet the needs of man through the balanced use of our resources.

ECONOMIC STUDIES

The following economic studies are needed to provide information on critical economic relationships. A considerable amount of the work needed has already been accomplished or is underway. The essential task, however, is to expand, modify, and integrate what has been accomplished in order to provide answers relevant to the development, management, and use of water and related land resources.

Economic Projections

Considerable attention should be given to a continual updating and revision of economic projections. Key elements, such as population, technological change, services and production needs should be carefully examined and kept as current as possible. Regular

national assessments could be used to report upon monitoring activities.

Price-Income

Given the nature of demand for most agricultural commodities, the price and income impacts of any program that influences agriculture production levels is crucial. Special attention should be given to farm income as it is influenced by alternative levels of water development.

Resource Analytical System

An analytical system is needed that is capable of evaluating the competitive advantages of the California Region in the production of goods and services closely related to water and related land development. An essential element would be a model that would indicate the cost of production of agricultural products under a range of assumptions and the land use patterns resulting from least-cost allocation of production within the Region.

Interindustry Analysis

A continuation of the work with input-output models is needed to provide a more complete understanding of important relationships among industries and a technique for evaluating the economic consequences of a broad range of alternatives.

WATER SUPPLY

Prospects are good for providing the people of the California Region adequate water supply of good quality. There are numerous alternative water supply sources that may prove feasible in the future. In addition, there are large quantities of surface water that could be developed for water supply where it proves to be the best alternative. Short-term needs appear to have generally been met. This provides the time and opportunity to more intensely investigate alternative ways to meet the more distant water related

needs and to develop plan elements most consistent with the objectives of the people of the Region.

High priority should be given to studies of plan elements that show promise of substantial potential for meeting water supply requirements with a minimum of conflict with other purposes and environmental degradation. The goal of these studies should be to provide by 1980 information on plan elements that will permit making the next major decisions regarding the source of additional developed water supply. Both supply increasing and requirement reducing alternatives should be considered. These studies should also include reliable estimates of potential and costs as well as the impact on each of the multiobjectives.

Surface Development

Construction should continue on those major water projects currently underway including features of the Central Valley Project and State Water Project as well as numerous smaller projects under construction by Federal, State and local agencies. These projects will generally provide adequate water to meet the Region's water requirements until at least 1980 and more likely until 1990. Thus, no additional major water supply facilities need to be provided in the immediate future. There is however a need to construct additional conveyance facilities to deliver present water supplies to certain areas.

Ground Water

Development of new ground-water basins or large increases in pumpage on a sustained yield basis does not appear promising as a future source of new water supplies. However, there are almost one billion acre-feet of ground water in storage ranging in depth from 200 to 1,000 feet. Significant quantities of water could be extracted by mining ground water.

The potential role of these large ground-water deposits is unknown at this time. A study is needed that can consider the question; What can we do with out large non-renewable ground-water resources that will best satisfy the future needs of the Region? Mining ground water might prove to be analogous with mining oil whereas in future years other means of water supply will become feasible in a manner that nuclear power is replacing oil.

The study should therefore consider the other possible methods of obtaining new water supplies and give careful consideration to short-term (less than 50 years) use of ground water.

Waste Water Reclamation

Waste water reclamation appears to have the capability to provide a water supply at a reasonable price and in some areas fits well with the desirability of reducing sewage disposal costs by eliminating or reducing the need for costly outfall sewers in the ocean. Reconnaissance and feasibility studies should be continued and construction of facilities encouraged when they are proved to be economically feasible. By 1980 more reliable data should be developed on potential and cost of future waste water reclamation. Preferable uses for reclaimed waste water include industrial, agricultural, and ground-water recharge for sea-water intrusion control; and park, freeway and golf-course watering. Direct reuse for domestic purposes, even after tertiary treatment, is not advisable, without further study of possible physiological effects.

Geothermal

Preliminary investigation results indicate that there is a possibility of providing several million acre-feet of water annually from the Colorado Desert Subregion utilizing geothermal wells. This source lies deep underground in the southern portion of the Region where municipal and industrial requirements continue to grow and costs of imported water supplies are high. Studies of

geothermal resources are continuing but considerably more information is needed and should be obtained to assess this alternative. One objective of these studies should be to develop reliable estimates of cost and a more specific measure of potential by the target date of 1980.

Desalting

Because of the world-wide implications of developing economically feasible water supplies using desalting techniques, continued development and testing of alternative techniques is highly desirable. The State of California and the Office of Saline Water have a program to develop a large prototype desalting plant. It will provide new and factual information on capital and operating costs and operational characteristics that will be invaluable for evaluating the role of desalting in providing water supply in the Region and in the entire Pacific Southwest.

Weather Modification

Water production by weather modification is a very appealing alternative, especially if it can be used as a tool for increasing runoff in dry years utilizing storage and distribution systems already in place. The magnitude of the potential is uncertain but its cost may be low. Flexibility of such an alternative permits varying the level of operation in conjunction with need. Several studies of weather modification are currently in progress in the Southwest and some programs are active in California. If the results of these studies continue to be encouraging, the studies should be expanded to determine the region-wide potential of weather modification as a supplemental water supply source.

Improve Existing Project Operation

Coupled with improved hydrometeorological forecasting and ground-water basin management, increases in the Region's effective

water supply may be possible by improving existing project operations. Continuing emphasis should be placed on determining ways to improve existing project operations and to integrate surface water project operation with ground-water operation. Weather modification activities should be considered with these studies.

Reduce Irrigation Requirements

Irrigated agriculture will continue to be the largest user of water in the Region. Attention should be given to methods for the individual farmer to improve the efficiency of water use and the reduction of crop irrigation requirement on his farm. Studies need to be made to determine the feasibility of a program that would result in an increase of the efficiency of irrigation as an alternative to additional water supply development. These studies should be limited to those areas where inefficient methods actually result in significant losses of regulated water supplies.

Reduce Per Capita M&I Use

The largest increase in water requirements is for municipal and industrial uses. Since the California Region per capita use is already considerably higher than the national average, limiting water development requirements by reducing projected increases in M&I unit use of water may have considerable potential. This potential and its associated costs, including a measure of the possible loss in consumer satisfaction, should be established before the next major water supply decisions are necessary, possibly by 1980.

A consumer education program should be implemented to encourage domestic and industrial consumers in critical areas to conserve water. Advantage could be taken of the large amount of press coverage and interest of special groups in environment and conservation. The program should be designed and implemented for the purpose of statistical testing of both the short and intermediate term effects of a program of consumer education on water use rates.

Other means of stabilizing M&I water use should also be investigated. These include: the effect of price charged for water on quantity used, the potential and associated cost of metering M&I water, and the potential for conserving water by zoning or regulations. As the density of population has increased in some metropolitan areas of the Region, there has been, and probably will continue to be, a reduction in per capita M&I use as the outside use of domestic water is reduced.

Increase Crop Yields

Advances in agricultural technology and resulting increases in crop yields are extremely important in estimating future water requirements. Agricultural research programs should receive continuing emphasis to investigate the feasibility of establishing new or more intensive research aimed at increasing crop yields per acre-foot of water as a means of meeting agricultural production needs without increasing water supply requirements. Investments in technological advances in crop production may well be the preferable way of meeting long-term needs for food and fiber.

Continuing Action Program

A plan of action for water resources development beyond 1980 would depend in large part upon; (a) results of studies and research in the aforementioned water supply fields; and, (b) future population and economic growth and its implications for future water requirements.

While it is not possible to accurately predict what will happen beyond the next decade, it is envisioned that the plan of action will be continued in a form generally similar to that described herein or a slightly modified manner to reflect events as they occur.

If regional growth should occur in a pattern such as depicted by the Base Plan projections, (see Figure 6) early decisions will

be required regarding sources of additional water supplies. The nature of current information would most likely dictate that additional surface water supplies be developed for out-of-stream use. However, a more likely pattern of regional growth, at least in the immediate future, is that represented by the Series D-1970 projection. In this case, current water supplies are sufficient to allow us a decade of time to improve our knowledge of alternative sources and enable planners to make wiser decisions regarding future use of resources.

FLOOD CONTROL

A comprehensive flood control program comprises both elements that are independent of and elements that are dependent upon water resources development serving other functions. In addition, the several flood control measures have varying effects upon environmental qualities and their requirements are dependent in varying degrees upon future growth rates and patterns. The most critical factor in developing a plan of action for flood control is the potential for providing flood control storage. Single-purpose flood control reservoirs are generally not economically feasible and such storage must usually be planned as part of a multiple-purpose reservoir, often with water supply as the principal function. Elsewhere in this appendix it is shown that existing and under-construction projects can furnish adequate water supply to the Region until about 1980 for Base Plan projections, 1988 for Series D-1970 projections, and about 1995 for OBERS projections. Consequently, the need for starts of new water supply reservoirs could be as soon as 1975 and as late as about 1990, depending upon which projection proves accurate.

Accordingly, a plan of action for flood control for the California Region would consist primarily (at least for the next decade or so) of a continuation of present structural and non-

structural programs, generally as outlined in the PLANS AND ALTERNATIVES section of this appendix, and a continuing evaluation of flood damages. During this period special attention should be given to the effect of flood control measures upon the environment and to the need for multiple-purpose reservoirs in which flood control would be a function. It is possible that some multiple-purpose reservoirs might be built earlier than needed for water supply because of the immediate need for flood control. As possible alternatives to flood control storage, special emphasis should be placed upon planning efforts for levees, channel improvements, watershed treatment, and flood plain regulation programs. Future studies should include possible impacts of flood control upon the environment, possible means to mitigate such impacts, and ways that flood control programs and measures could enhance environmental qualities. The long-range plan of action would be, essentially, a continuation of the prior studies, evaluations and programs and an updating and reevaluation of plans and programs as and when deemed necessary.

RECREATION

The Plan of Action is designed to implement the means described earlier as necessary to satisfy recreation needs for each time frame. Water surface needs and augmentation of river flows for recreation are tied directly to water development projects. The land and development needs can be met independently of water development projects. Unmet recreation needs can be satisfied providing that extensive modification of existing legal, institutional and financial arrangements occurs as outlined in Appendix XII, Recreation.

All recreation programs must recognize the special consideration of needs for open space, natural areas, including wild or scenic rivers, wilderness and cultural areas.

Approximately 63 percent of the estimated 2020 recreation development deficit is Class I and urban related. Federal agency programs can satisfy only one percent of this need. The burden of satisfying the remaining non-Federal development needs as well as acreage acquisition needs then must fall heavily upon local government. Water plans that develop reservoir recreation provide lands generally in Class II. Some Class I needs will be served if reservoirs are located near enough to urban centers.

Implementation of plans for meeting needs has been separated according to the role that should be assumed by several levels of government.

The Federal role would include expansion of: (1) direct funding and grants for recreation, (2) making Federal non-recreation land available for recreation, (3) establishing national recreation areas nearer urban centers, and (4) allowing increasing non-reimbursable portion of project costs assignable to recreation.

The State role would include: (1) authorization of urban recreation funds on a matching basis, (2) reorganization of State recreation agency for greater emphasis on urban needs, (3) acquisition of beach lands on a first priority basis, (4) initiation of a program to determine urban recreation needs, (5) transfer of those State facilities which do not have state-wide significance to local control, (6) transfer of suitable left-over parcels of non-recreation land to park and recreation use, and (7) lease of usable portions of freeway rights-of-way to local agencies on a long-term nominal cost basis.

The local role would include: (1) increased citizen participation, (2) formation of regional park agencies, (3) determination of the most efficient means of financing programs to meet local recreation needs, (4) city government-school district agreements for joint use of education and recreation facilities, (5) increasing neighborhood recreation facilities in "inner-city areas", (6)

providing for cultural, artistic, creative opportunities, field sports, and playground games, and (7) developing mobile recreation facilities as a stopgap measure only. Local governments could also devise tax benefits for landowners who allow use of their land for public recreation, or provide for a tax deferral program in lieu of a preferential assessment.

The private sector can develop private lands for recreation profit committing land to such uses as campgrounds, resort areas, picnic areas, golf courses, swimming pools, fish ponds and others. The private sector is actively soliciting many new recreation ventures.

More intensive studies to resolve recreation problems are especially needed in heavily populated areas and in areas where resource development requirements are in direct conflict with preservation goals. Studies of the North Coastal Subregion are of particular importance because of possible water development projects on potential wild and scenic rivers.

Problems associated with urban areas, the preservation of open space and the inappropriate development of the coast, all indicate that more intensive studies of the South Coastal, San Francisco Bay and Central Coastal Subregions are needed.

FISH AND WILDLIFE

Ongoing and planned programs of State and Federal fish and wildlife management agencies are estimated to satisfy only part of the future demand for sport fishing and hunting. These programs include construction of fish hatcheries, acquisition and expansion of waterfowl management areas and refuges, development of access to fishing and hunting areas, species management, pesticide and water quality surveillance, habitat improvement, enhancement of fish and wildlife on military lands, and enforcement of fish and wildlife legislation and regulations. Similar fish and wildlife programs are being implemented by land management agencies. Many

of these programs take place on public domain and national forest lands which are managed for multiple uses.

A supplemental program, over and above ongoing and planned programs, could meet all fishing and hunting needs except for waterfowl hunting. The estimated cost of such a program for the period 1966-2000 is almost $81 million.

Additional programs are needed beyond the supplemental program if the fish and wildlife angling and hunting opportunities and the fish and wildlife resources are to be improved. These additional programs are the responsibility of federal and state agencies and should be initiated.

Additional research and investigation is needed in fish and wildlife resources and habitat. All agencies planning road construction, logging, water projects and other similar activities should be required to allocate sufficient planning time and funds for studies to determine the effects of those activities upon all fish and wildlife resources. Results of these studies could be used to modify and guide the planned activities.

The quality of the angling and hunting experience will be degraded, and/or bag limits and length of season reduced in certain areas for certain species unless plans are prepared and implemented that aim beyond the level projected for the supplemental program.

ELECTRIC POWER

A suggested mix of alternative means to satisy projected power needs is contained in Appendix XIV, ELECTRIC POWER, and summarized in this appendix. Needs for power are projected to increase from 19 to 26 times by 2020, resulting in a per capita increase in installed capacity from 1 kw in 1965 to about 8 kw by 2020. Because of the widespread concern regarding the effect of such a large increase in power production upon the environment, studies of the possibility of reducing this projected increase in power consumption

should be undertaken -- initially on a reconnaissance level and later on a feasibility level. Such studies must take into account both the positive and negative aspects of a lesser rate of power consumption and should include means of reducing increases in per capita use, effects upon the natural environment, and effects upon the well-being of the people.

The early establishment of environmental standards is needed to provide the basis for evaluating the alternatives and identifying costs associated with meeting these standards.

Harnessing geothermal sources should receive immediate attention; first at the reconnaissance level and later at the feasibility level. These studies could be conducted as part of the alternative water supply studies dealing with geothermal resources.

Other aspects of a plan of action for electric power, and certainly of equal importance with that mentioned above, include an intensification of present efforts to further reduce possible pollution (thermal and chemical - air and water) from thermal powerplants and research in advanced technology methods of power production.

WATER QUALITY AND HEALTH FACTORS

A plan of action aimed at protecting and improving water quality and health factors has varying degrees of compatibility with other related functions. Minimum flow requirements to preserve or enhance fishery habitat will often satisfy water quality needs, and quality standards established to protect public health and safety also serve to enhance recreation.

Water quality and pollution control is highly sensitive to future regional growth, and success of any action program will be highly dependent upon the desires of the people in the Region. If the people want clean water and a quality environment, they must

express their desires and be willing to pay the price, either in terms of financial support, reduction in per capita use, or both. A primary element of this plan is public education regarding the cost of clean water and the alternatives.

Establishment of enforceable and realistic water quality standards is a must, with periodic reevaluation of the standards for possible changes to reflect changes in knowledge and outlook. Recognizing the local nature of some problems it will be desirable to enact joint power agreements among existing governmental entities, or create regional agencies with authority to plan, design, construct, and operate comprehensive water pollution and water quality control systems.

Structural solutions to problems will of course also be necessary. The magnitude of such facilities is included in the project development plan. Funding from local, state, and federal sources must keep pace with demands for timely expansion and improvement of waste water collection, treatment, and disposal systems. (The preceding text on unmet needs shows municipal and industrial waste treatment to be woefully lagging.)

Rapid expansion of waste water reclamation facilities, especially in the southern portion of the Region, should be encouraged. Direct reuse for domestic purposes may not be advisable but requirements for several other purposes can be satisfied.

Detailed water quality operation studies are needed for all major existing and proposed conveyance and storage units in the Region. This would include the waste water flows generated by water development projects. Studies should also be conducted in treatment technology, ocean disposal practices, thermal pollution, and irrigation drainage treatment needs.

Special consideration should be given to providing adequate waste collection, treatment and disposal systems for marina and port developments. An appropriate part of the cost of these

facilities should be project costs. Furthermore, provision should be made for adequate drainage, collection, and treatment facilities for agricultural lands requiring drainage. Major areas requiring these facilities are in the San Joaquin and Tulare Basin Subregions with lesser magnitude problems in the North Coastal and Central Coastal Subregions. Treatment of irrigation waste waters in these areas would provide protection of surface and ground-water resources and/or provide additional water for other uses. Costs should be included in water resource development costs.

NAVIGATION

Navigation needs, and consequently navigation facility requirements are generally independent of program requirements for other functions. A navigation plan of action can, therefore, be developed relatively independent of other functional requirements. Such a plan of action would consist of an adoption of the plan elements set forth in the PLANS AND ALTERNATIVES section of this report (and in Appendix XVII, Navigation) as the basic navigation plan for the Region with timely authorization and funding to permit implementation of the program. Future studies should include the effects of navigational facilities upon the environment and consideration of possible legal and institutional changes as suggested in Appendix XVII. Navigational needs and requirements should be reevaluated on a continuing basis and the development plan revised as and when required.

SHORELINE PROTECTION AND DEVELOPMENT

Plans formulated for protection and development of the shoreline are generally compatible with other functions and with environmental quality goals, and are relatively insensitive to future regional growth. Accordingly, a plan of action for shoreline protection and development could include as its basis, the plan elements described in the PLANS AND ALTERNATIVES section of this

report (and in Appendix XVI, Shoreline Protection and Development). Timely authorization and funding would be necessary to permit implementation of the program. Future action would include study and consideration of possible legal and institutional changes as set forth in Appendix XVI, and reevaluation of shoreline needs and goals on a continuing basis with formulation of new plans as and when required.

LAND TREATMENT

A comprehensive land treatment program consists of certain elements specifically aimed at meeting projected needs for food and fiber, and other elements oriented directly to the protection of lands from erosion, sedimentation, and damages from wildfires.

Needs for land treatment programs associated with production of food and fiber depend upon future population and economic growth and the feasibility of other programs that would satisfy these needs. Because of these uncertainties, flexibility should be maintained in this phase of land treatment.

On the other hand, needs for land treatment programs associated with reduction in erosion, sedimentation and wildfire damage are not as closely associated with the level of future population. In addition, such programs generally do not conflict with other functional requirements or with environmental quality goals.

Accordingly, a plan of action for land treatment would consist of: (a) adoption of the plan elements set forth in PART V as the basic land treatment program for the Region; (b) continual monitoring of future land treatment needs associated with food and fiber production with corresponding adjustments to the scope and kinds of these programs; (c) continuation of research and studies of improved land treatment; and, (d) timely authorization and funding of required land treatment programs.

A COMMENT ON THE ROLE OF RESOURCE PLANNING

The framework study is explicitly concerned with meeting the needs of people for the next 50 years. Projections of needs for food, fiber, recreation, power, etc., are presented as those that must be met. Planning for the management, use and development of water and related land resources to meet these needs will presumably fulfill our responsibility to future generations. But first it might be well to ask - "What is our commitment to future generations?" Is it to assure that our children and their children after them are well-fed, well-clothed, and well-housed? Or, does our role as trustees of our nation's resources extend beyond these commitments?

In the following discussion, it will be argued that we have, for the most part, developed the technology and established the political and economic systems that can assure future generations of adequate goods and services. Our planning must recognize this and shift emphasis to the quality of man's relationship to his surroundings, i.e., environmental quality.

Each generation has become more affluent. The youth of today view as "unreal" the conditions experienced by most of today's older people when they were young. It is likely the grandchildren of today's youth will have the same feelings about the conditions that their grandfathers experienced. Today, technology allows us to feed and clothe ourselves with far less effort than at any time in history. Only a few decades ago, a majority of the people in the United States were engaged in agriculture. Now, less than 5 percent of the population are farmers. Yet, agriculture continues to produce more than we can consume or export at equitable prices. Huge government programs are used to limit production and increase farm income. Large quantities of surplus food and fiber are in storage throughout the country and substantial quantities of commodities are exported to other countries through various aid programs.

We are, indeed, fortunate that our problems are related to surpluses rather than shortages. Yet, we must recognize that farm surplus problems have existed continuously for several decades and in all likelihood will continue for some time to come.

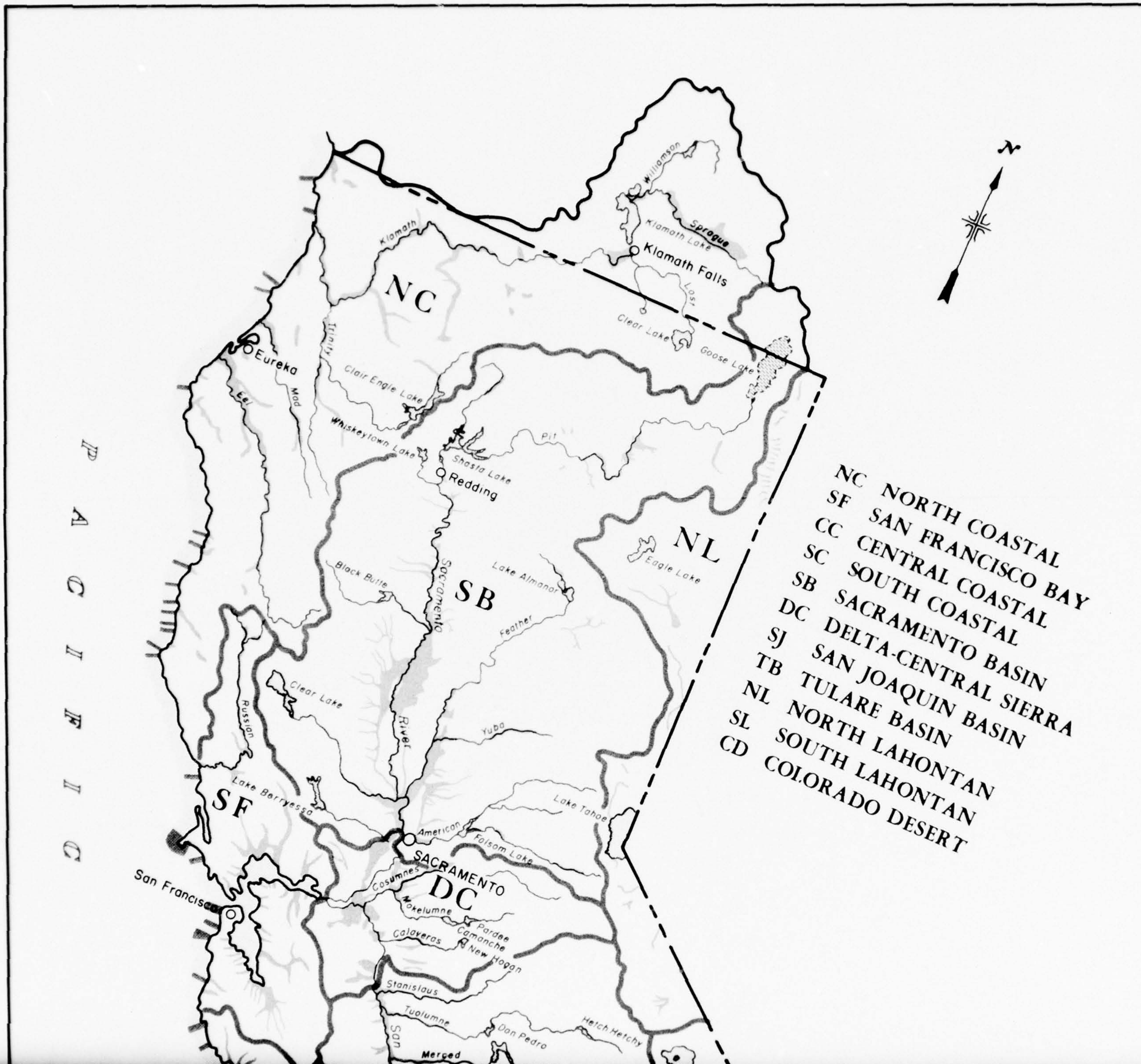
There is no question but that we must assure future generations the food, clothing, and housing they demand; and they will demand a lot. Per capita real income is expected to rise from \$3,000 to \$13,000 between 1965 and 2020 while in the same period population will increase from 2-1/2 to 3 times. These two elements combined mean that about 10 times as much goods and services will have to be produced as in 1965. Obviously, if our projections are any where near correct, our children will be far better off than we are in terms of income and the goods and services that they can buy. Do we really have a major responsibility for providing future generations with 4 times as much real income per person as we have today?

While each generation becomes more and more affluent, they also experience growing environmental problems. The seriousness of the current "environmental crisis" is constantly being pointed out by newspapers, books, television, and environmental groups. The technological revolution that made possible the level of production we enjoy today has been partially responsible for some of the environmental problems which seem very difficult and costly to solve in the 1970's. Conversely, this same technological revolution and our resulting affluence also provide us with the means and opportunities to solve these environmental problems.

If today's production levels have produced an environmental crisis, how much more difficult will it be to maintain a quality environment when output is 10 times greater as projected for 2020? The challenge is staggering and failure will mean disaster.

In summary, we must recognize two important facts in our long-range planning. First, we have basically solved the problem

of production. The free enterprise system, modified to varying degrees, now has the potential to provide the goods and services to meet expanding demand. Future generations, like this generation, may have individuals that do not have an adequate standard of living, but this is a problem of distribution -- not production. Second, in solving the problem of production we have created a serious problem relating to the quality of life. Free enterprise alone will not solve the environmental problems. As stewards of our natural resources, we all must make sure that our actions preserve or enhance the quality of the environment for ourselves and for future generations.



N
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SC SOUTH COASTAL
SB SACRAMENTO BASIN
DC DELTA-CENTRAL SIERRA
SJ SAN JOAQUIN BASIN
TB TULARE BASIN
NL NORTH LAHONTAN
SL SOUTH LAHONTAN
CD COLORADO DESERT
NC
SB
NL
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Klamath Falls
Klamath Lake
Williamson
Sprague
Lost
Clear Lake
Goose Lake
Klamath
Trinity
Clair Engle Lake
Whiskeytown Lake
Shasta Lake
Redding
Pit
Eureka
Mad
Eel
Black Butte
Sacramento
River
Lake Almanor
Feather
Eagle Lake
Clear Lake
Yuba
Russian
Lake Berryessa
Lake Tahoe
American
Folsom Lake
SACRAMENTO
Cosumnes
Mokelumne
Pardee
Camanche
New Hogan
Calaveras
Stanislaus
Tuolumne
Don Pedro
Hetch Hetchy
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San Francisco
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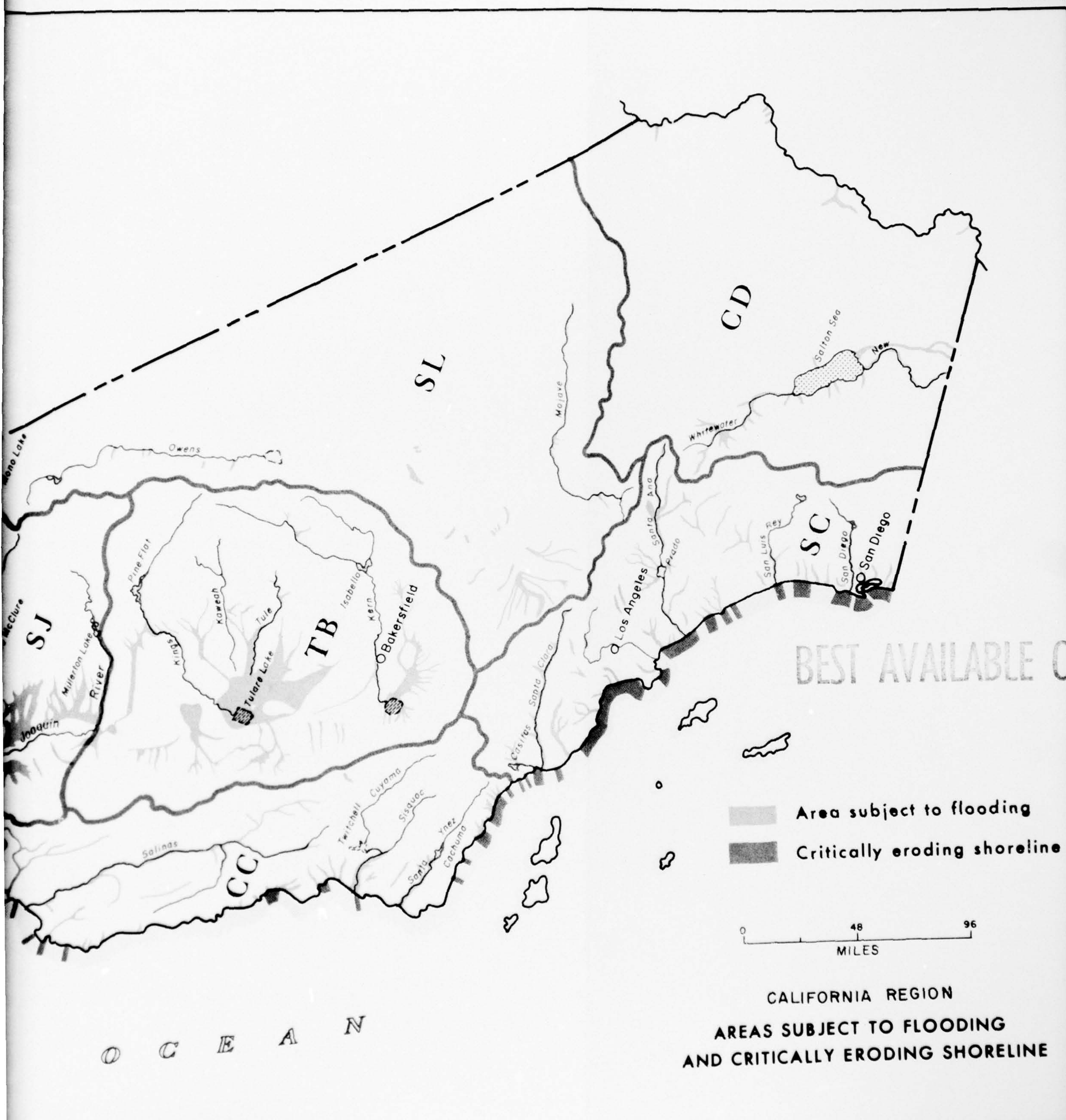
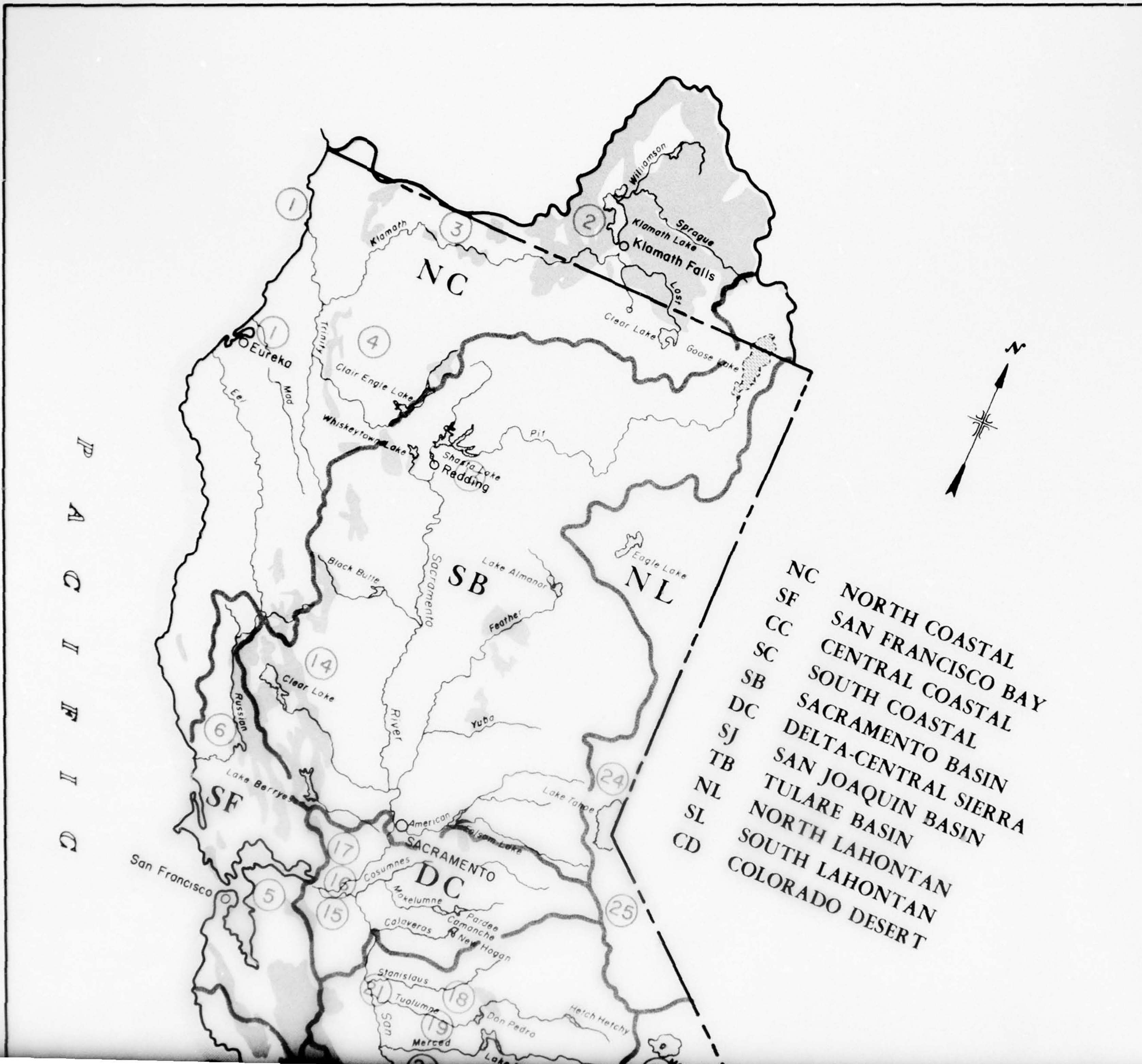
MAP 2



CALIFORNIA REGION

AREAS SUBJECT TO FLOODING AND CRITICALLY ERODING SHORELINE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Whiskeytown Lake
Shasta Lake
Redding
Pit
Black Butte
Sacramento
River
Lake Almanor
Feather
Eagle Lake
Clear Lake
Russian
Yuba
Lake Berryessa
Lake Tahoe
American
Folsom Lake
SACRAMENTO
San Francisco
Cosumnes
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New Hogan
Calaveras
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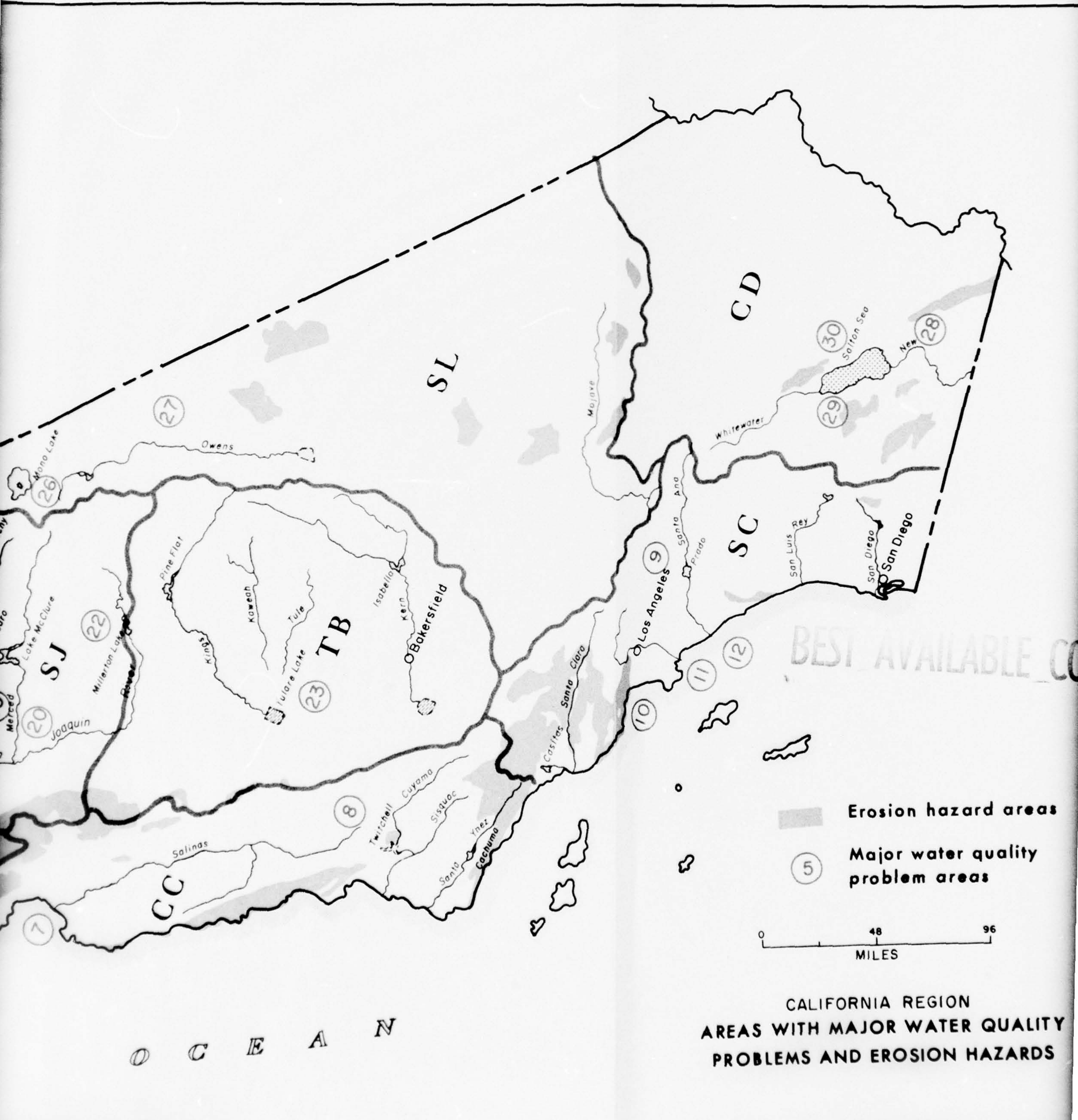
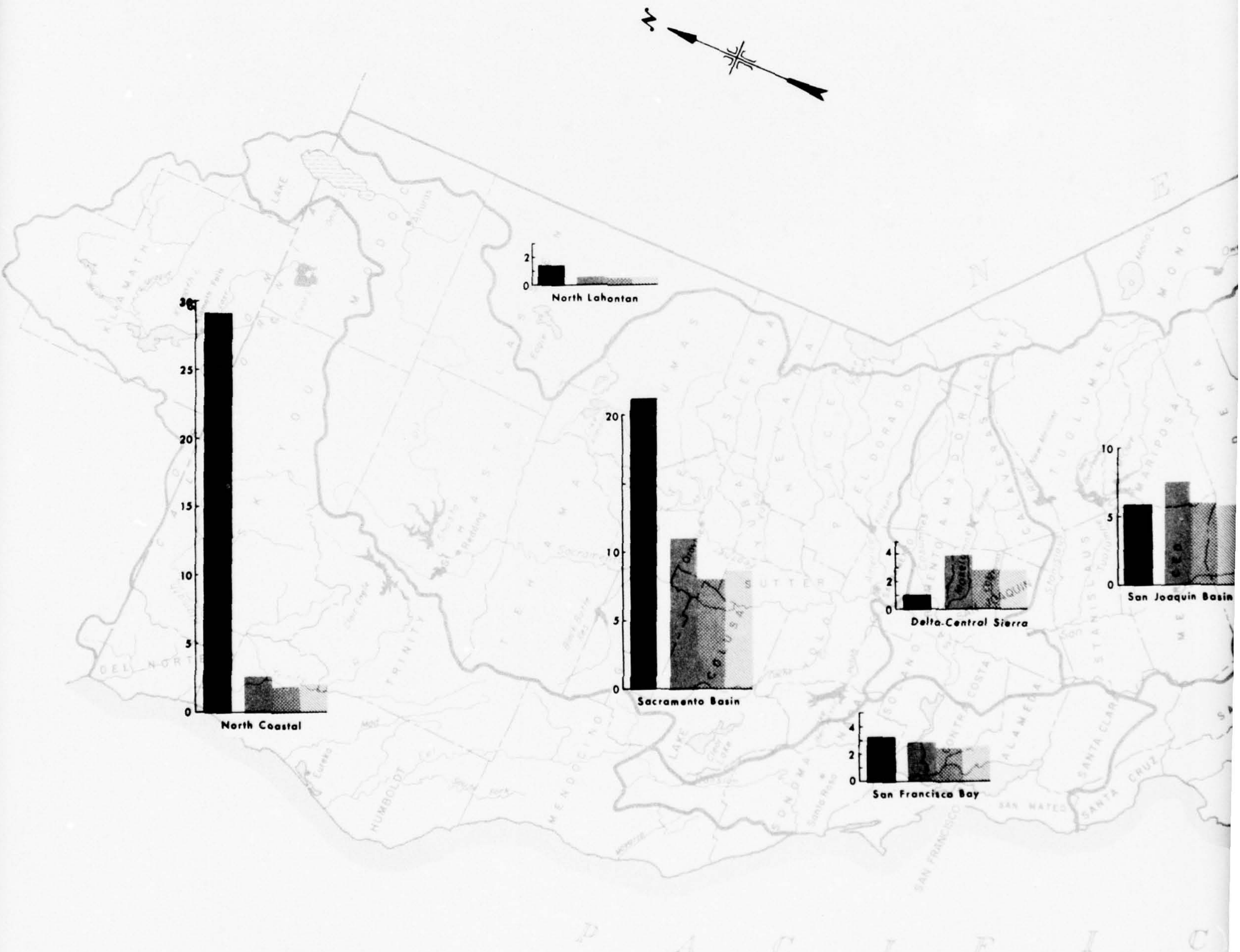
Tuolumne
Don Pedro
Hetch Hetchy
San
Merced



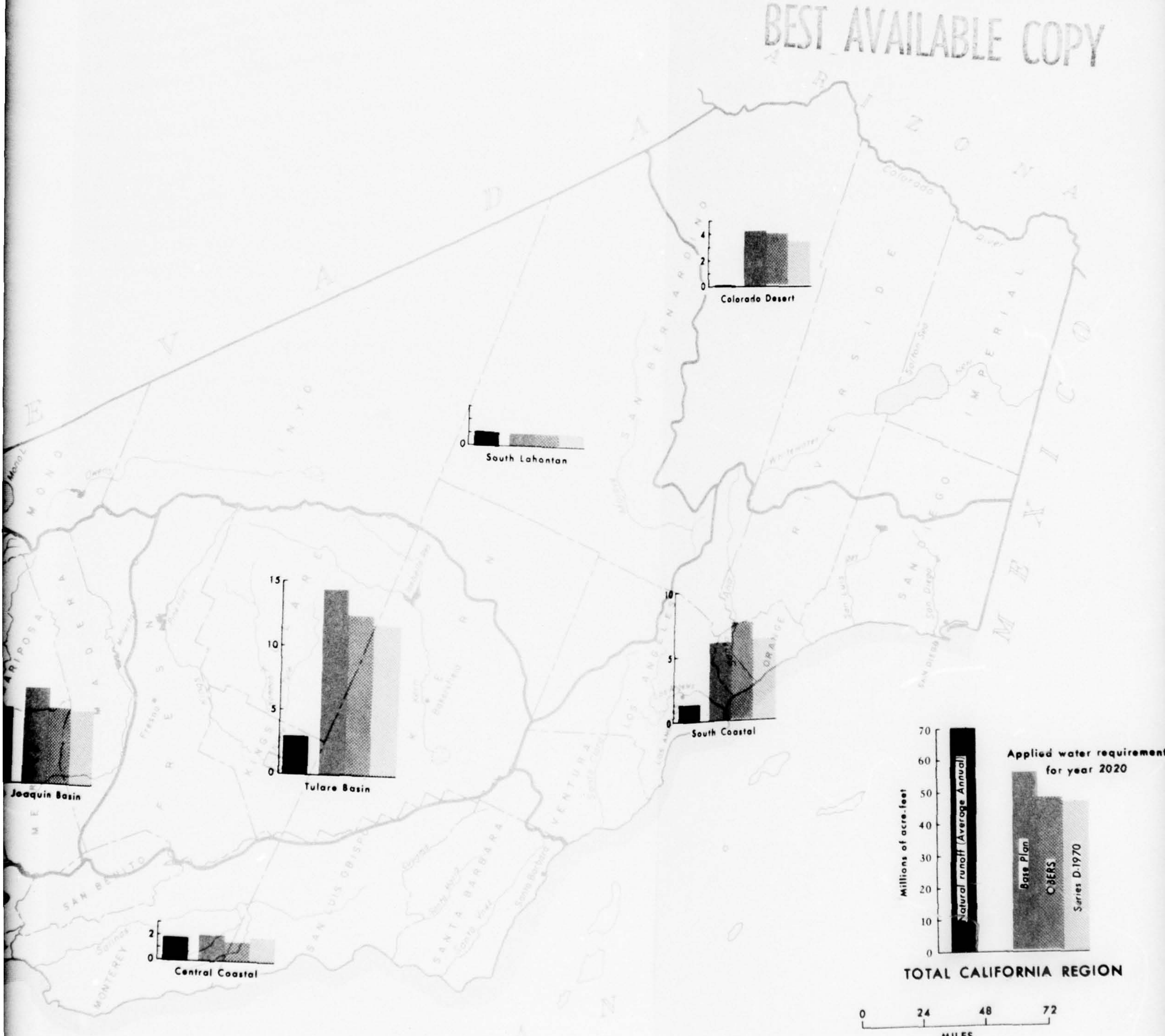
CALIFORNIA REGION

AREAS WITH MAJOR WATER QUALITY PROBLEMS AND EROSION HAZARDS

2

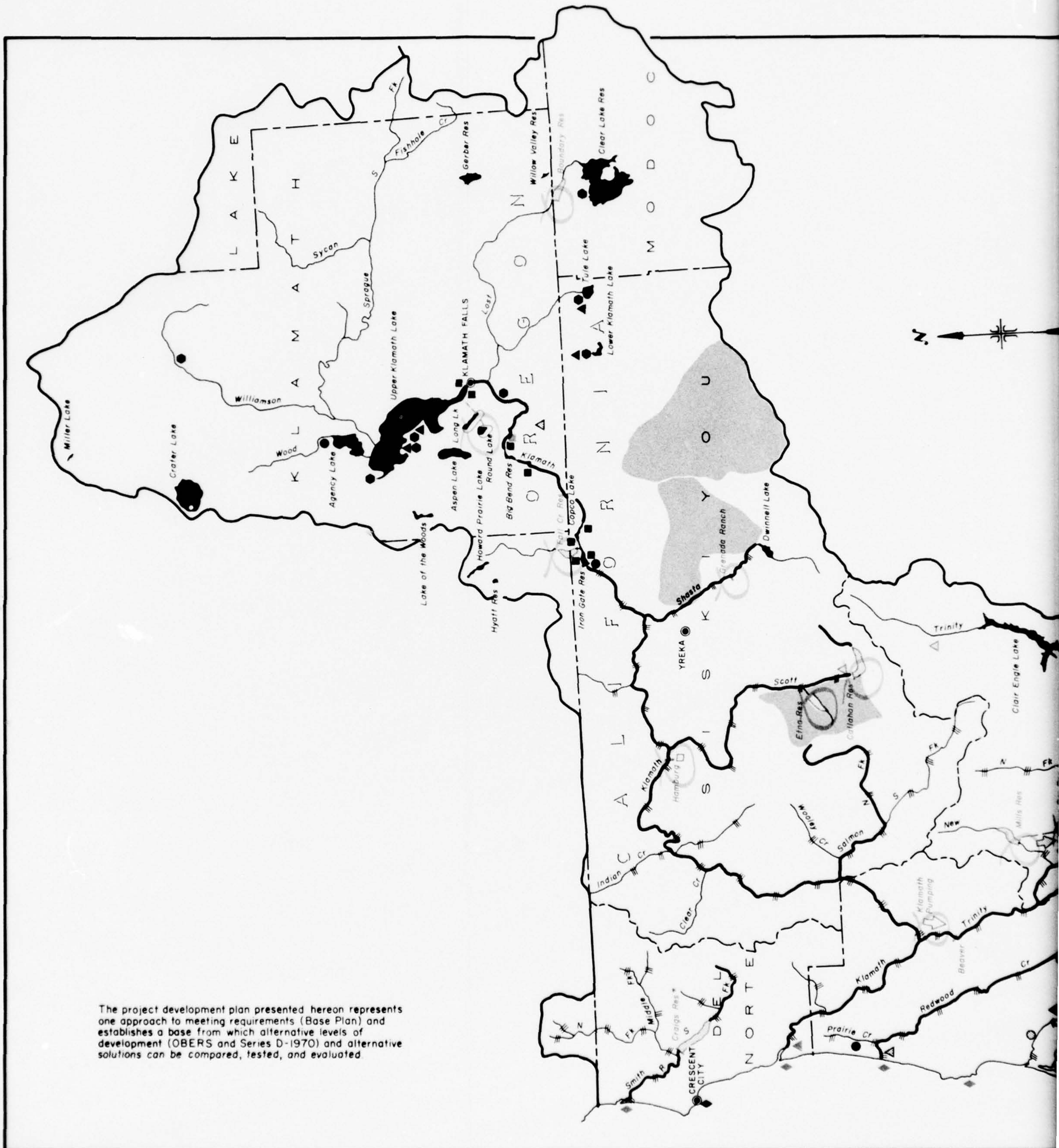

North Lahontan
North Coastal
Sacramento Basin
Delta-Central Sierra
San Joaquin Basin
San Francisco Bay
P A C I F I C

MAP 4



CALIFORNIA REGION

NATURAL RUNOFF AND
2020 APPLIED WATER REQUIREMENTS



The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated.

MA

CALIFORNIA REGION
NORTH COASTAL, SUBREGION
PROJECT DEVELOPMENT PLAN

2

The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated.

MAP 6

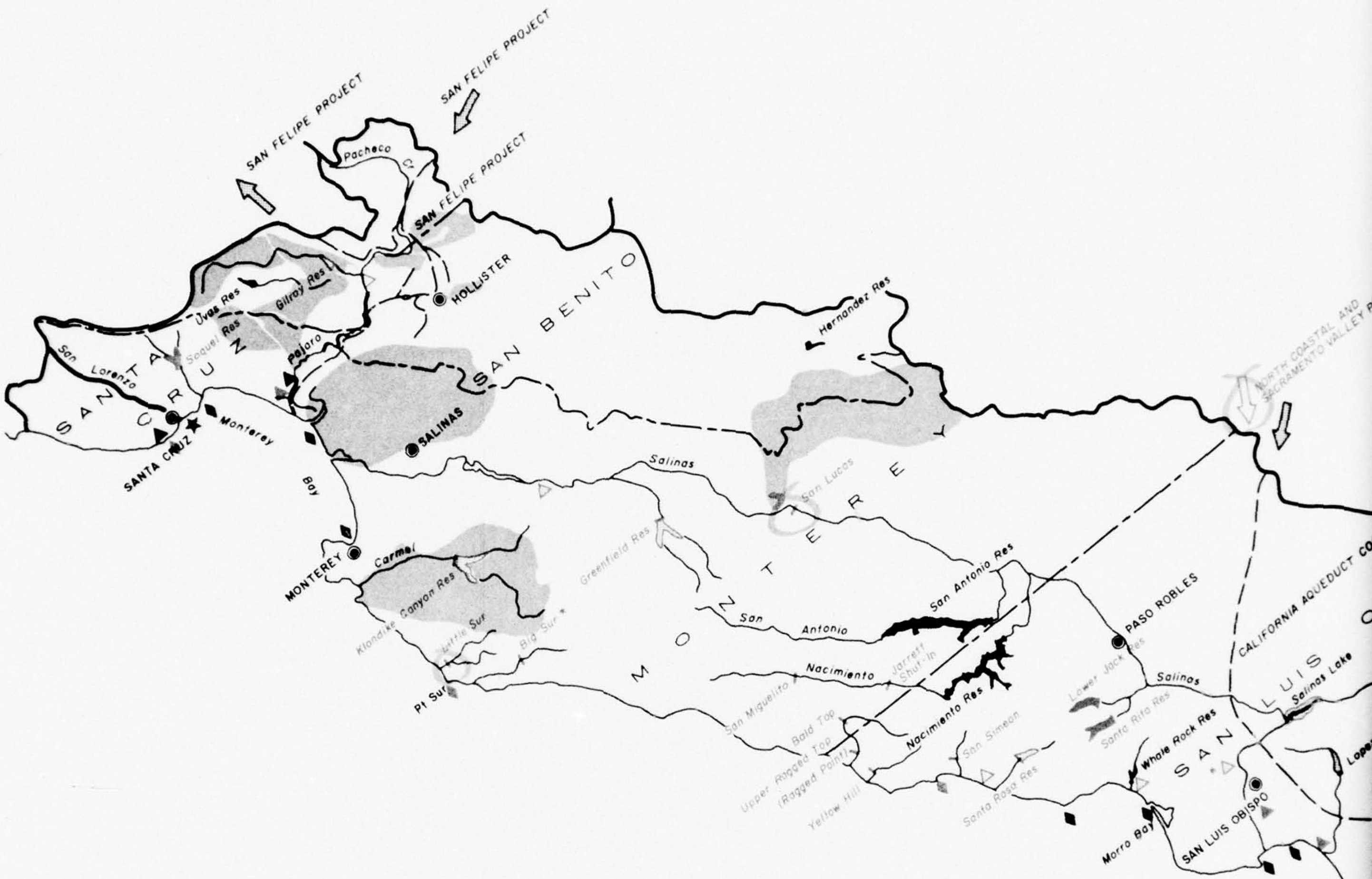
	1965 Existing	1965 Authorized or Under Constr	FUTURE 1966 1980	FUTURE 1981 2000	FUTURE 2001 2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area					
Navigation feature			(1966-2020)		
Navigation channel			(1966-2020)		
Shoreline protection project					
Hydroelectric powerplant					
Watershed project			(1966-2020)		
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream					
Plan element not required to satisfy Series D-1970 projections			(1966-2020)		
Plan element changed in scope or timing to satisfy Series D-1970 projections			(1966-2020)		

CALIFORNIA REGION

SAN FRANCISCO BAY, SUBREGION

PROJECT DEVELOPMENT PLAN

2



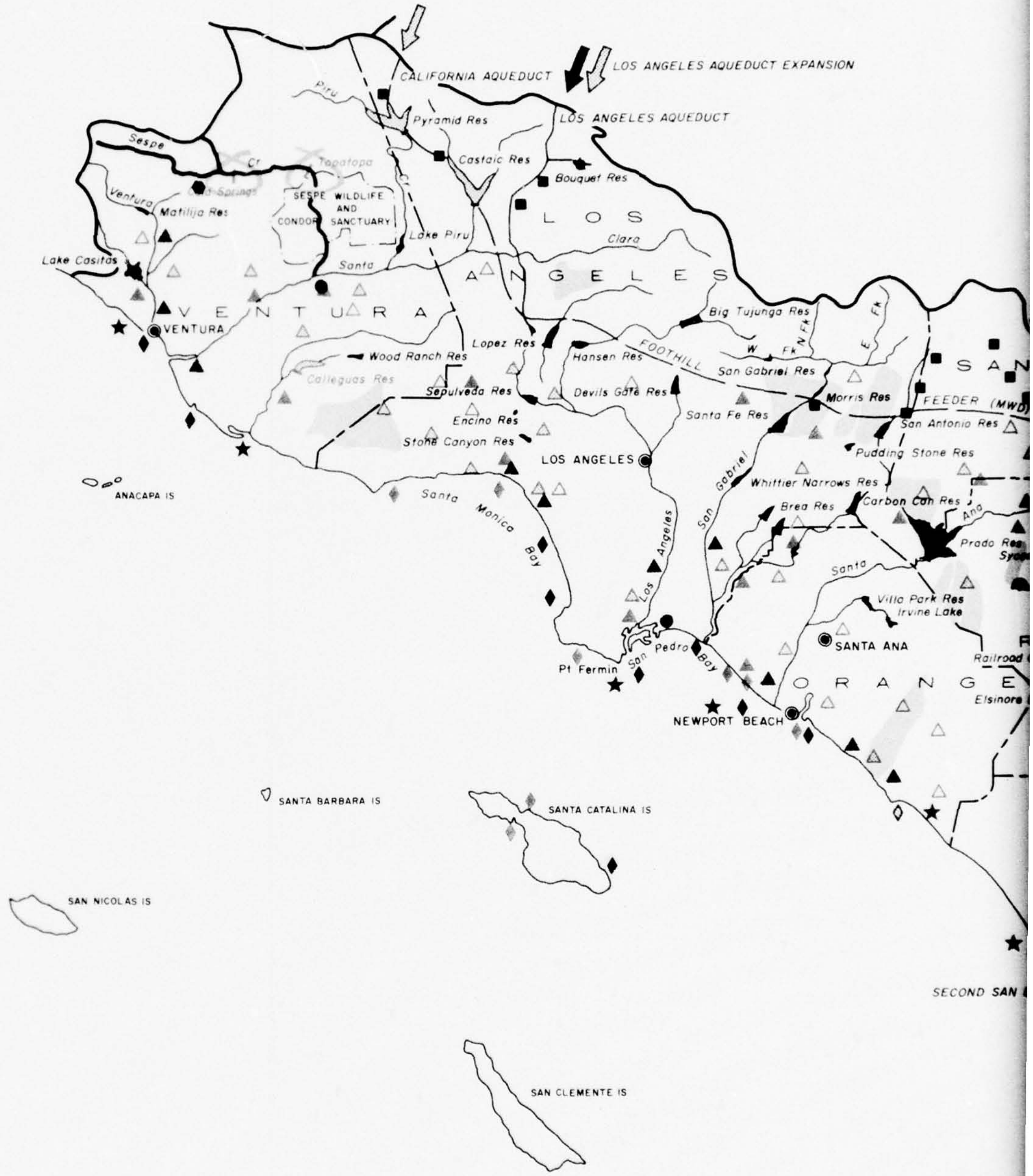
The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated.

	1965		FUTURE		
	Existing	Authorized or Under Constr	1966 1980	1981 2000	2001 2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area	None in this subregion				
Navigation feature				(1966-2020)	
Navigation channel	None in this subregion				
Shoreline protection project					
Hydroelectric powerplant					
Watershed project				(1966-2020)	
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream	None in this subregion				
Plan element not required to satisfy series D-1970 projections				(1966-2020)	
Plan element changed in scope or timing to satisfy Series D-1970 projections				(1966-2020)	

CALIFORNIA REGION
CENTRAL COASTAL, SUBREGION

PROJECT DEVELOPMENT PLAN

2



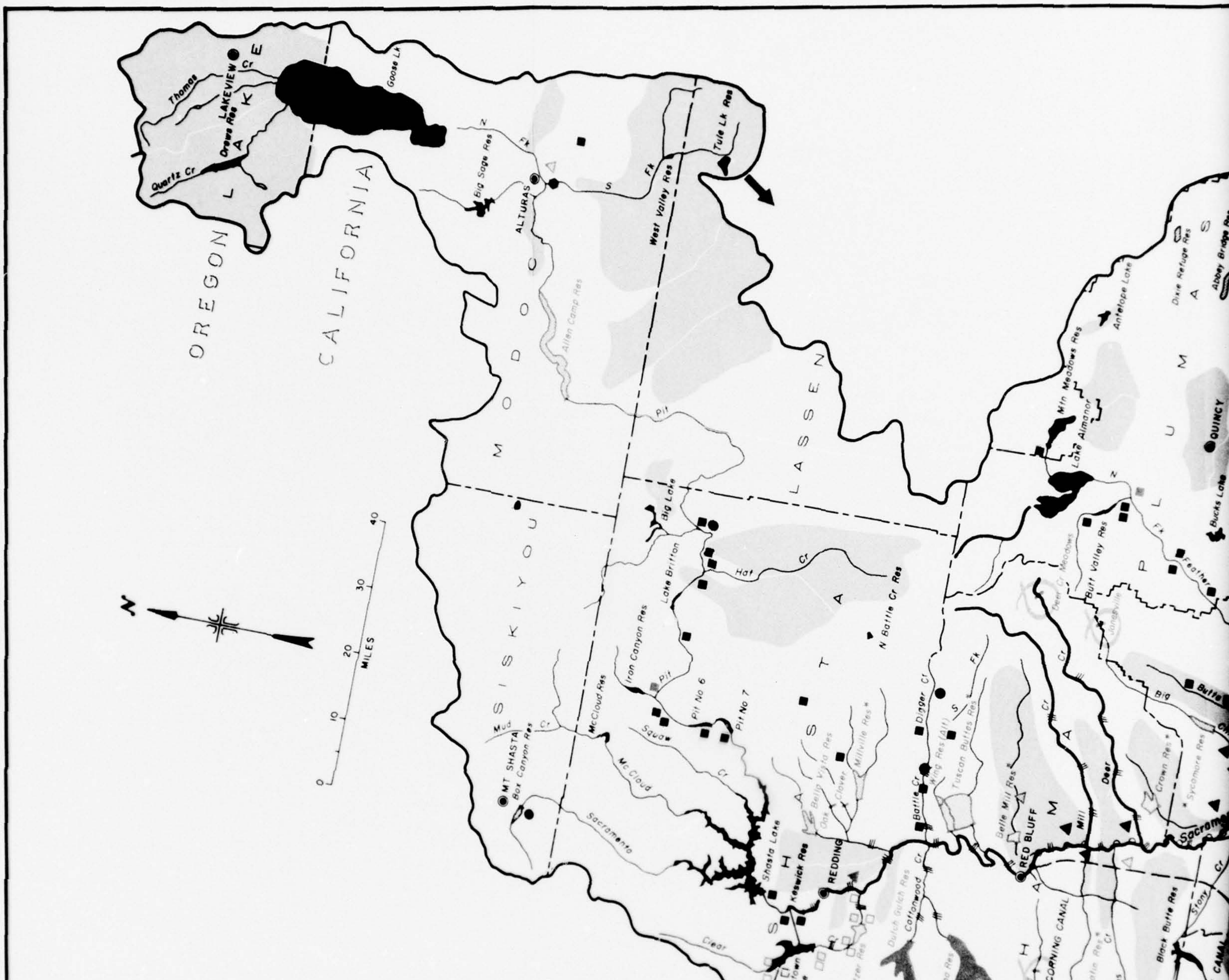
The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated

	1965		FUTURE		
	Existing	Authorized or Under Constr	1966 1980	1981 2000	2001 2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area					
Navigation feature				(1966-2020)	
Navigation channel		None in this subregion			
Shoreline protection project					
Hydroelectric powerplant					
Watershed project				(1966-2020)	
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream		None in this subregion			
Plan element not required to satisfy Series D-1970 projections				(1966-2020)	
Plan element changed in scope or timing to satisfy Series D-1970 projections				(1966-2020)	

CALIFORNIA REGION
SOUTH COASTAL, SUBREGION

PROJECT DEVELOPMENT PLAN

2



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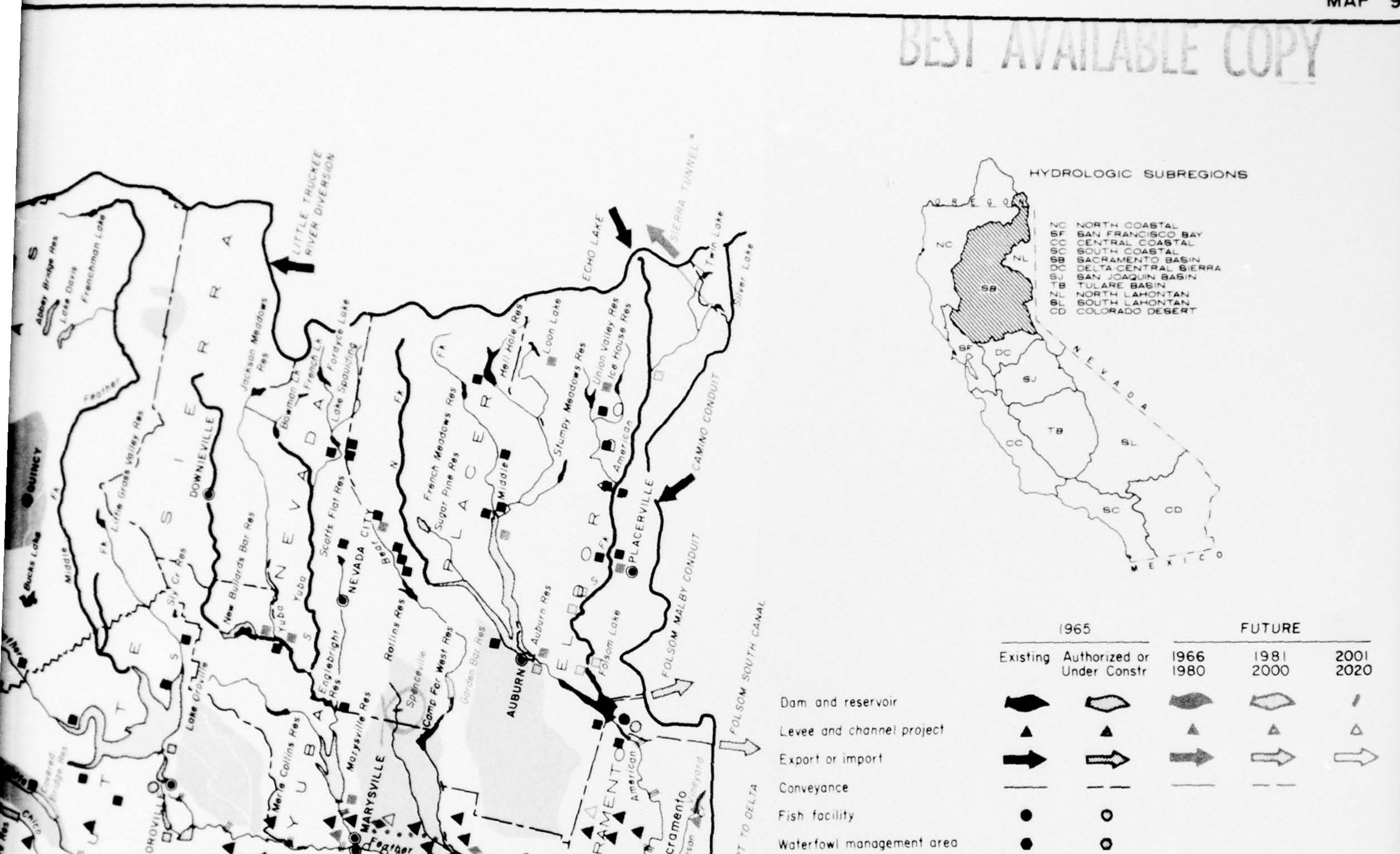

CALIFORNIA REGION
SACRAMENTO BASIN, SUBREGION
PROJECT DEVELOPMENT PLAN

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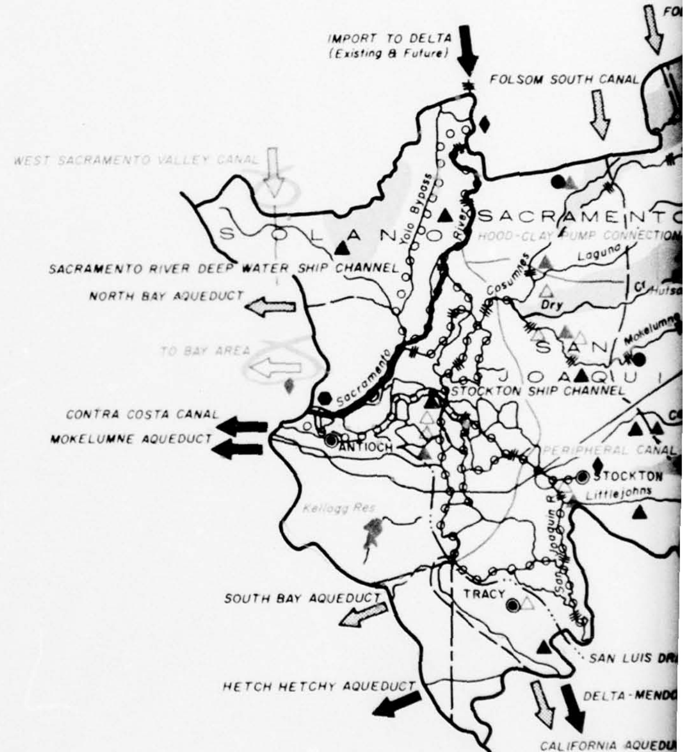
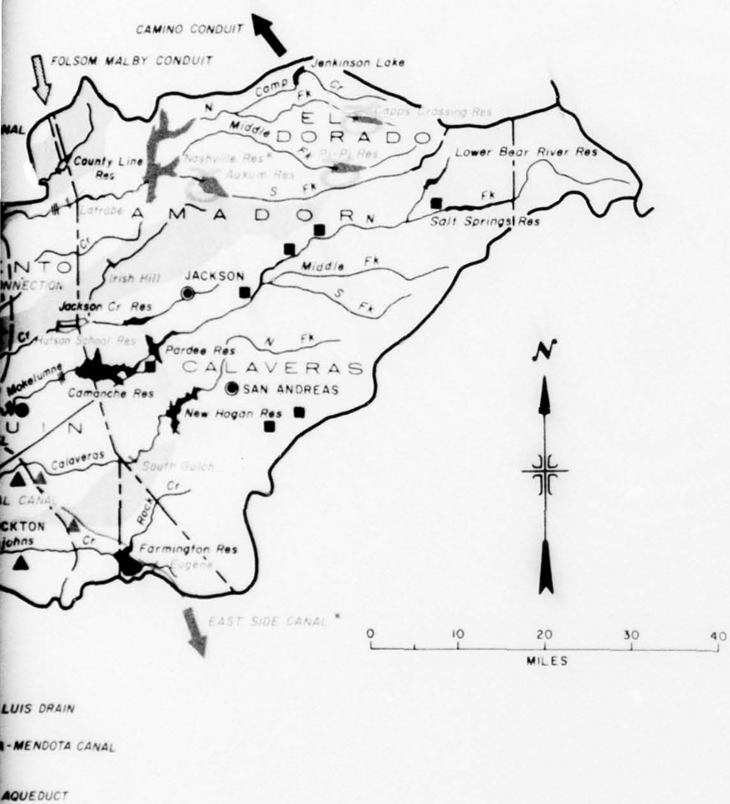
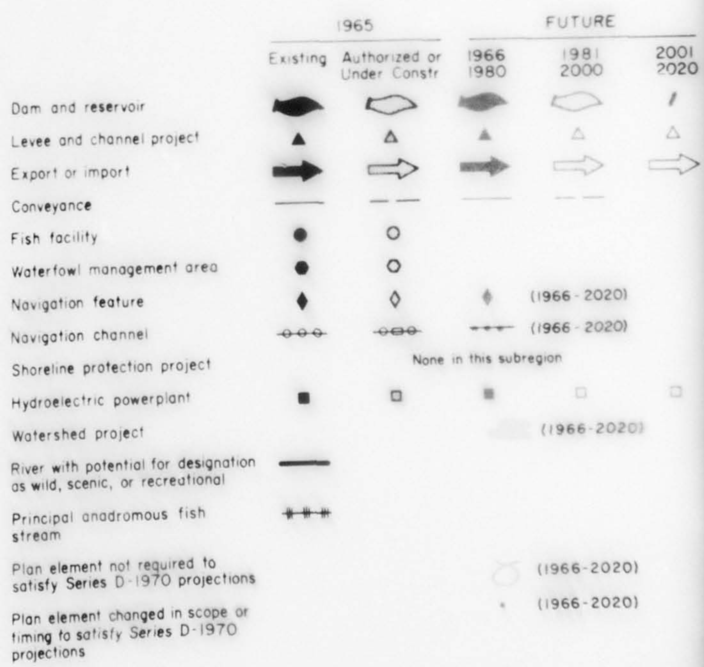


The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated.

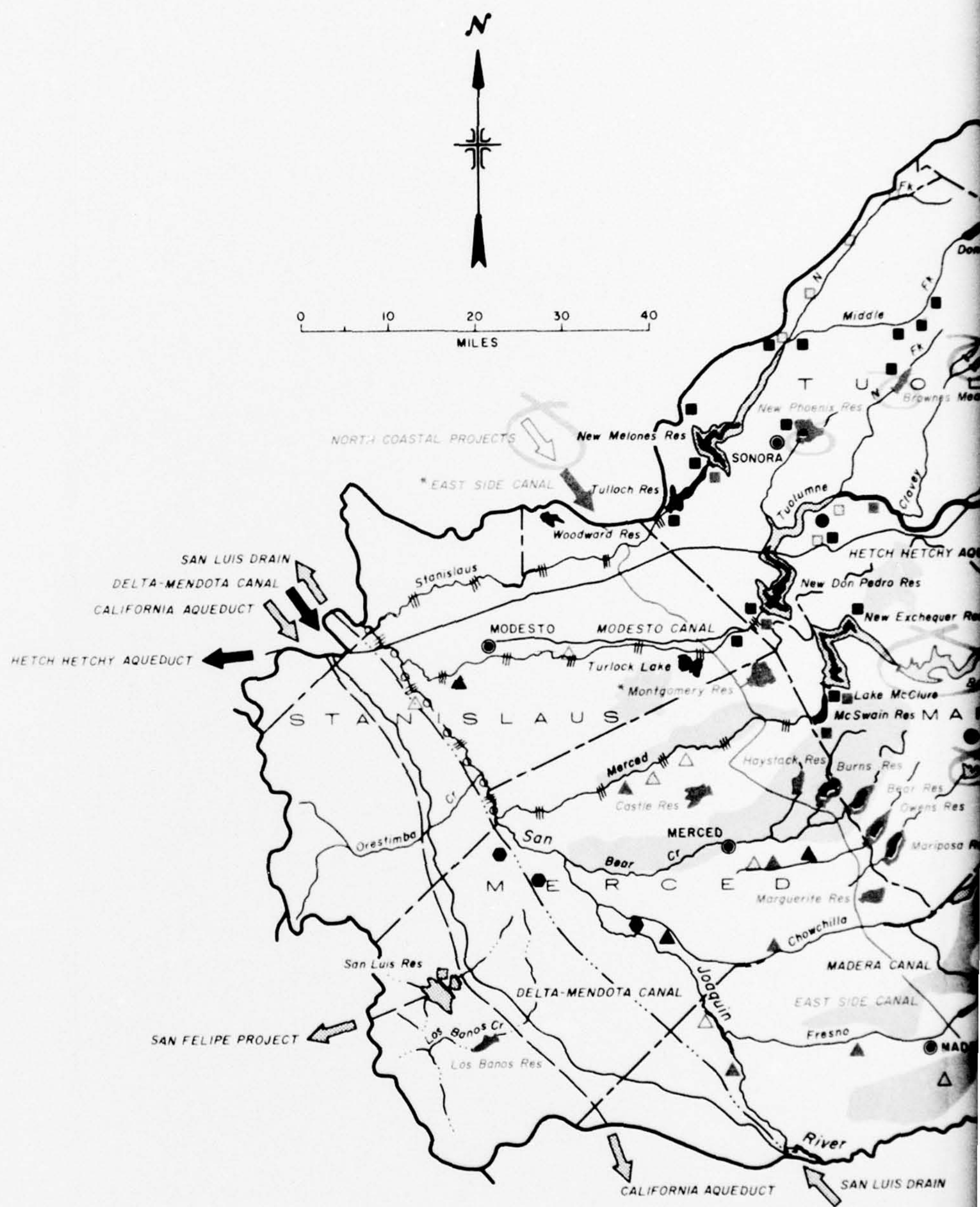




CALIFORNIA REGION

DELTA-CENTRAL SIERRA, SUBREGION

PROJECT DEVELOPMENT PLAN



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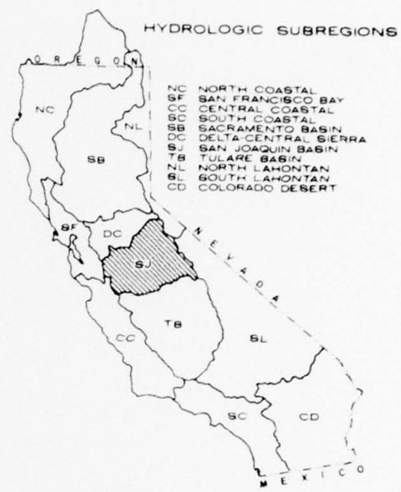
MAP



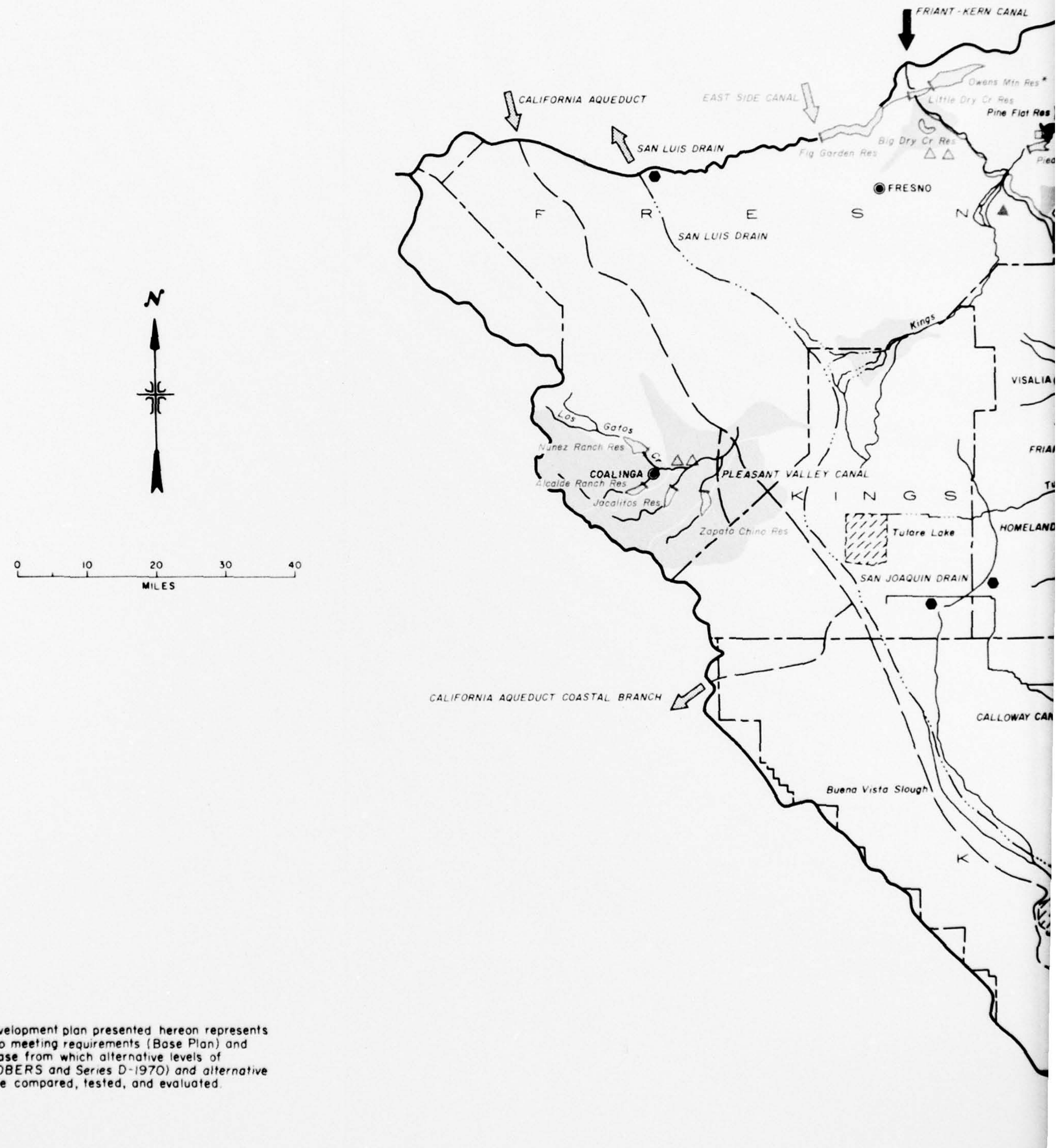
	1965 Existing	1965 Authorized or Under Constr	FUTURE 1966–1980	FUTURE 1981–2000	FUTURE 2001–2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area					
Navigation feature	None in this subregion				
Navigation channel			(1966-2020)		
Shoreline protection project	None in this subregion				
Hydroelectric powerplant					
Watershed project			(1966-2020)		
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream					
Plan element not required to satisfy Series D-1970 projections			(1966-2020)		
Plan element changed in scope or timing to satisfy Series D-1970 projections			(1966-2020)		

CALIFORNIA REGION

SAN JOAQUIN BASIN, SUBREGION

PROJECT DEVELOPMENT PLAN

2



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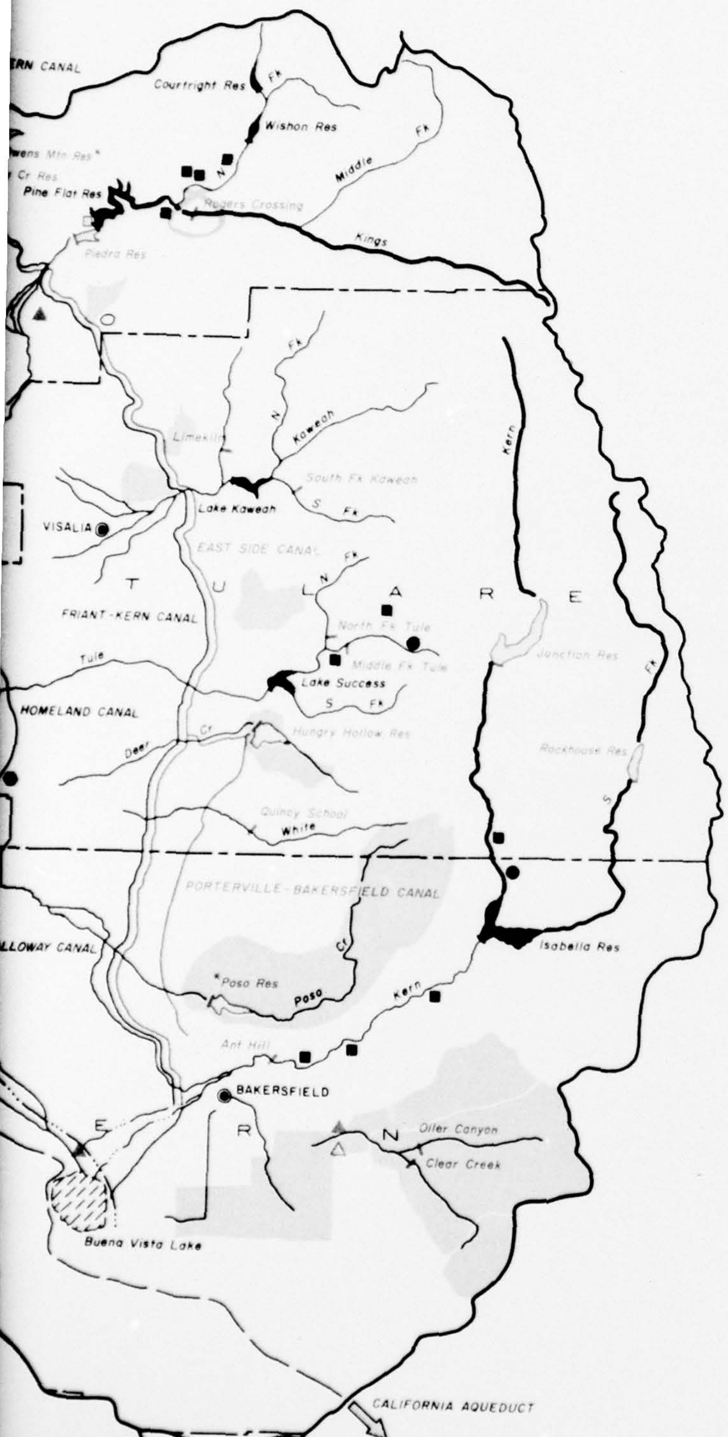
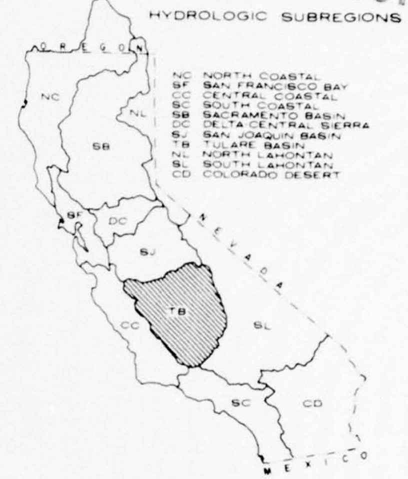
1





	1965 Existing	1965 Authorized or Under Constr	FUTURE 1966 1980	FUTURE 1981 2000	FUTURE 2001 2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area					
Navigation feature		None in this subregion			
Navigation channel		None in this subregion			
Shoreline protection project		None in this subregion			
Hydroelectric powerplant					
Watershed project			(1966 - 2020)		
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream		None in this subregion			
Plan element not required to satisfy Series D-1970 projections			(1966 - 2020)		
Plan element changed in scope or timing to satisfy Series D-1970 projections			(1966 - 2020)		

CALIFORNIA REGION

TULARE BASIN, SUBREGION

PROJECT DEVELOPMENT PLAN

2

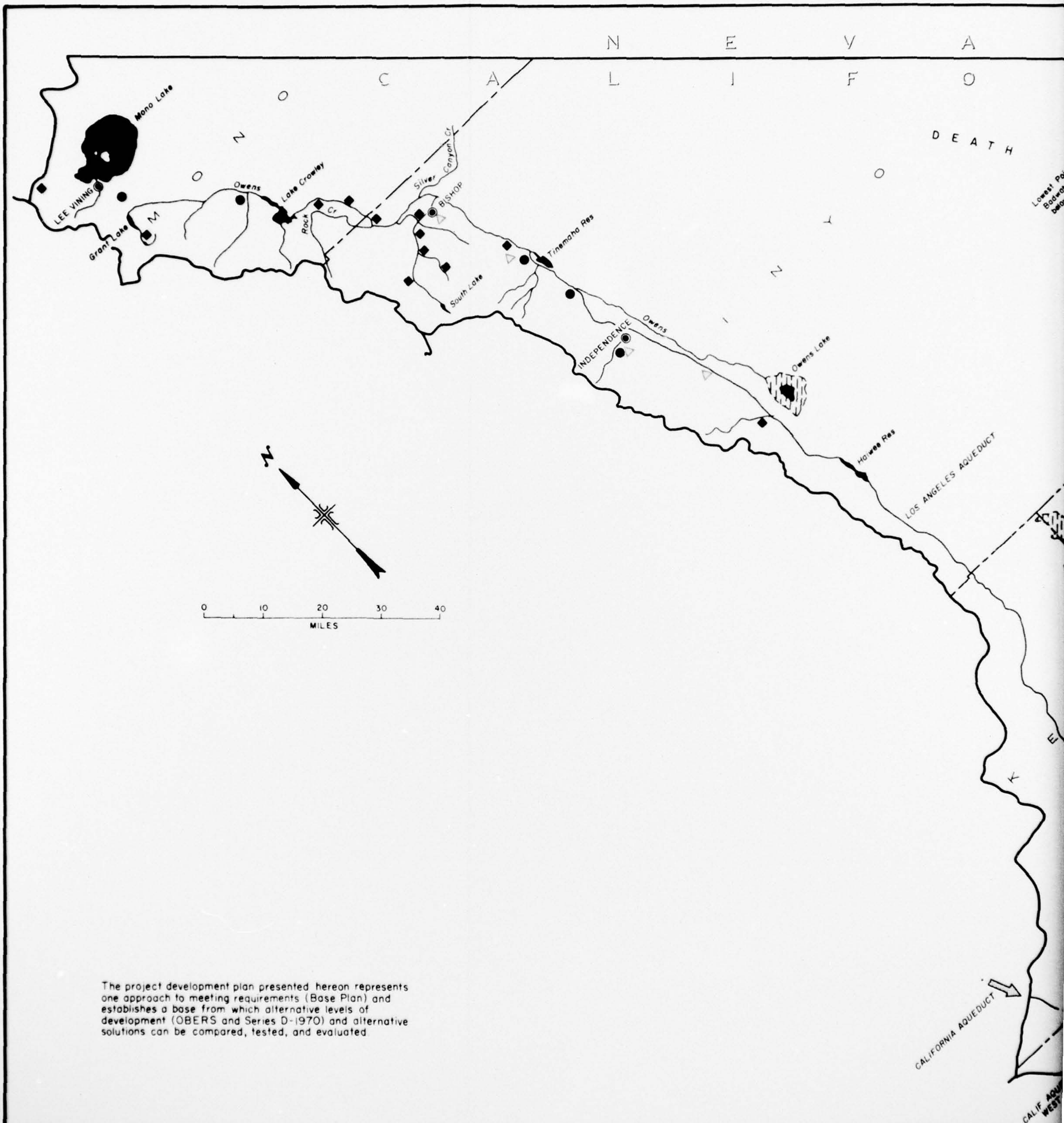
The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated.

	1965		FUTURE		
	Existing	Authorized or Under Constr	1966 1980	1981 2000	2001 2020
Dam and reservoir					
Levee and channel project					
Export or import					
Conveyance					
Fish facility					
Waterfowl management area					
Navigation feature			None in this subregion		
Navigation channel			None in this subregion		
Shoreline protection project			None in this subregion		
Hydroelectric powerplant					
Watershed project				(1966 - 2020)	
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream			None in this subregion		
Plan element not required to satisfy Series D-1970 projections			None in this subregion		
Plan element changed in scope or timing to satisfy Series D-1970 projections			*	(1966 - 2020)	

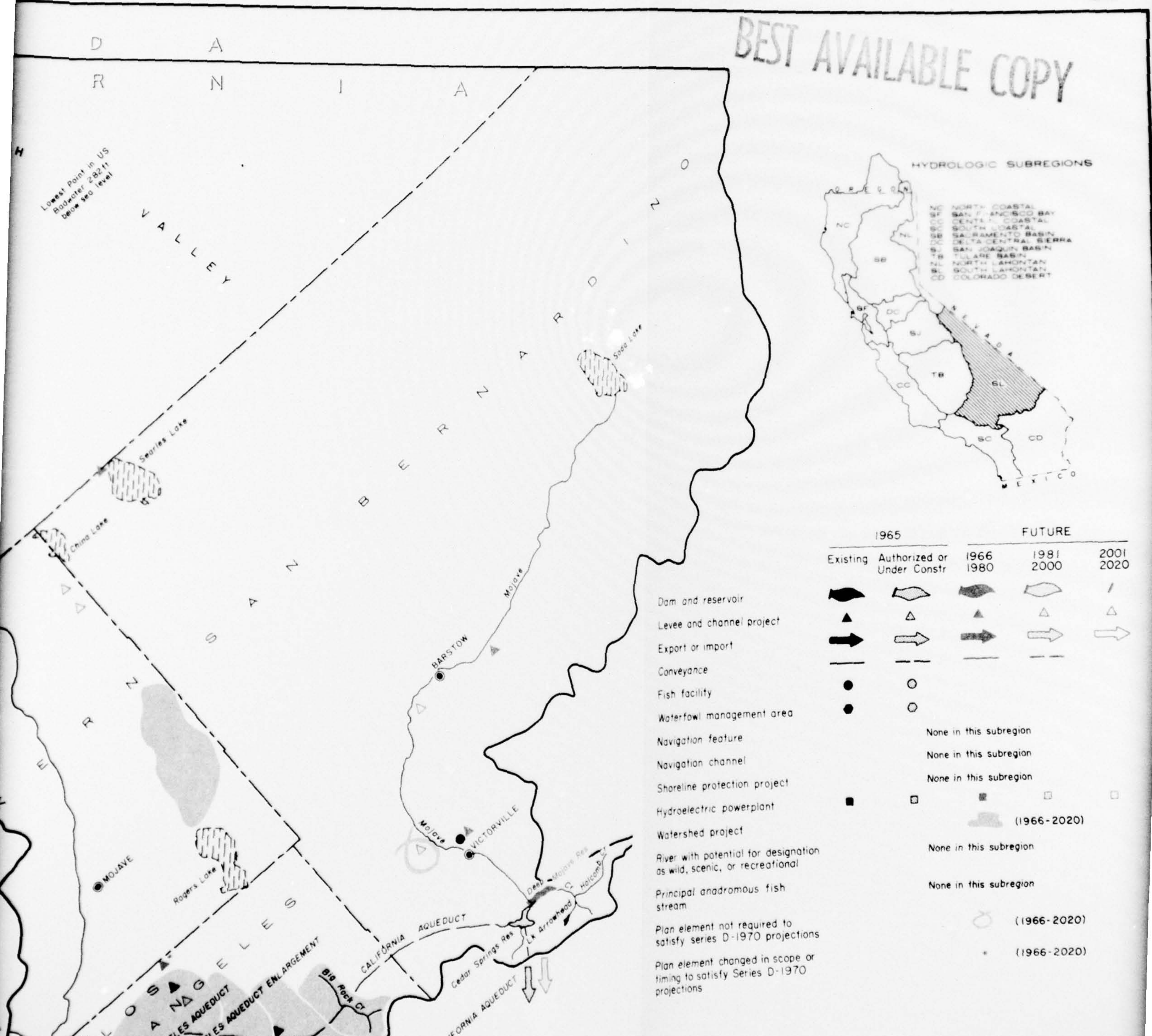
CALIFORNIA REGION
NORTH LAHONTAN, SUBREGION

PROJECT DEVELOPMENT PLAN

2



The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated



CALIFORNIA REGION
SOUTH LAHONTAN, SUBREGION
PROJECT DEVELOPMENT PLAN

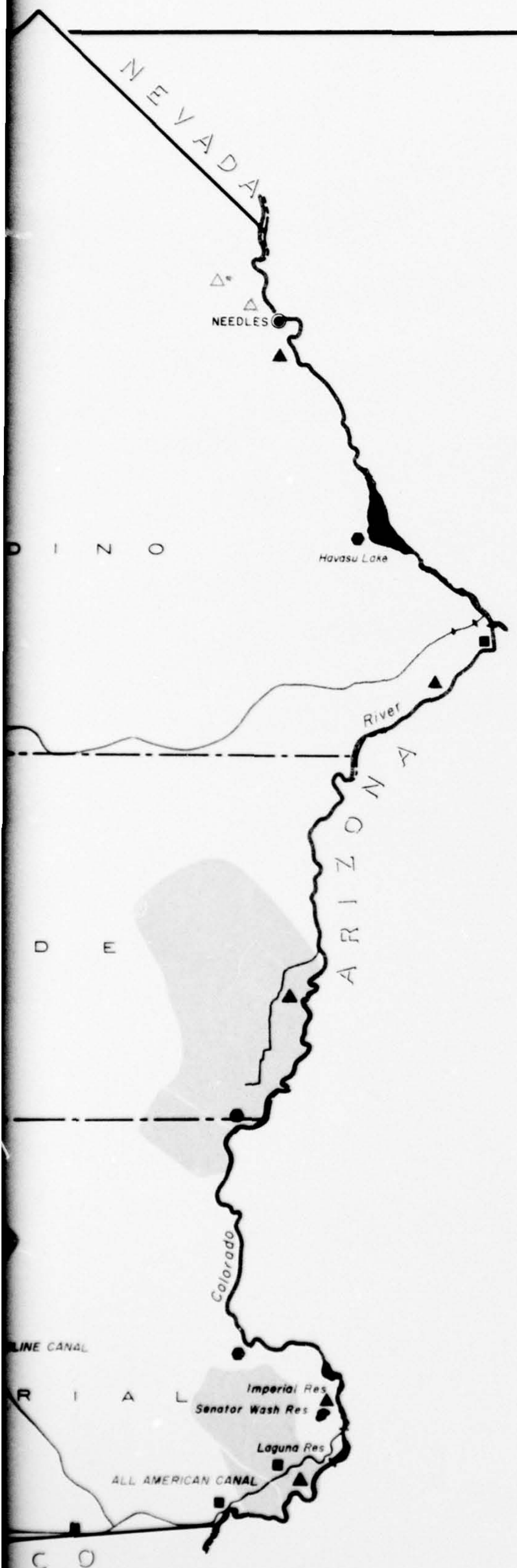
The project development plan presented hereon represents one approach to meeting requirements (Base Plan) and establishes a base from which alternative levels of development (OBERS and Series D-1970) and alternative solutions can be compared, tested, and evaluated

1


NEVADA
NEEDLES
Havasu Lake
SAN BERNARDINO
River
ARIZONA
Little Morongo
Big Morongo Res
Long Canyon Res
East Wide Canyon Res
COLORADO RIVER AQUEDUCT
PALM SPRINGS
Tahchevah Res
Whitewater
RIVERSIDE
Deep Canyon Res
La Quinta Res
COACHELLA CANAL
Coyote
Salton Sea
San
Felipe
Cr
New
Alamo
Colorado
EAST HIGHLINE CANAL
IMPERIAL
Imperial Res
Senator Wash Res
WEST SIDE MAIN CANAL
Laguna Res
ALL AMERICAN CANAL
EL CENTRO
SAN DIEGO
MEXICO
Dam and reservoir
Levee and channel
Export or import
Conveyance
Fish facility
Waterfowl managem
Navigation feature
Navigation channel
Shoreline protection
Hydroelectric power
Watershed project
River with potential
as wild, scenic, or
Principal anadromo
stream
Plan element not re
satisfy Series D-19
Plan element chang
timing to satisfy Ser
projections

BES

2



	1965 Existing	1965 Authorized or Under Constr	FUTURE 1966 1980	FUTURE 1981 2000	FUTURE 2001 2020
Dam and reservoir					
Levee and channel project	▲	△	▲	△	△
Export or import					
Conveyance					
Fish facility	●	○			
Waterfowl management area	●	○			
Navigation feature		(None in this Subregion)			
Navigation channel		(None in this Subregion)			
Shoreline protection project		(None in this Subregion)			
Hydroelectric powerplant	■	□	■	□	□
Watershed project			(1966 - 2020)		
River with potential for designation as wild, scenic, or recreational					
Principal anadromous fish stream		(None in this Subregion)			
Plan element not required to satisfy Series D-1970 projections			(1966 - 2020)		
Plan element changed in scope or timing to satisfy Series D-1970 projections			(1966 - 2020)		

CALIFORNIA REGION
COLORADO DESERT, SUBREGION
PROJECT DEVELOPMENT PLAN